NEW ZEALAND.—MARINE DEPARTMENT.

FISHERIES BULLETIN No. 7

The Reproduction, Growth, and Distribution of the Lemon Soles

(*Pelotretis flavilatus* Waite)

OF

TASMAN BAY and MARLBOROUGH SOUNDS.

BY

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With a Preface by A. E. Hefford, M.Sc., Chief Inspector of Fisheries and Director of Fishery Research.

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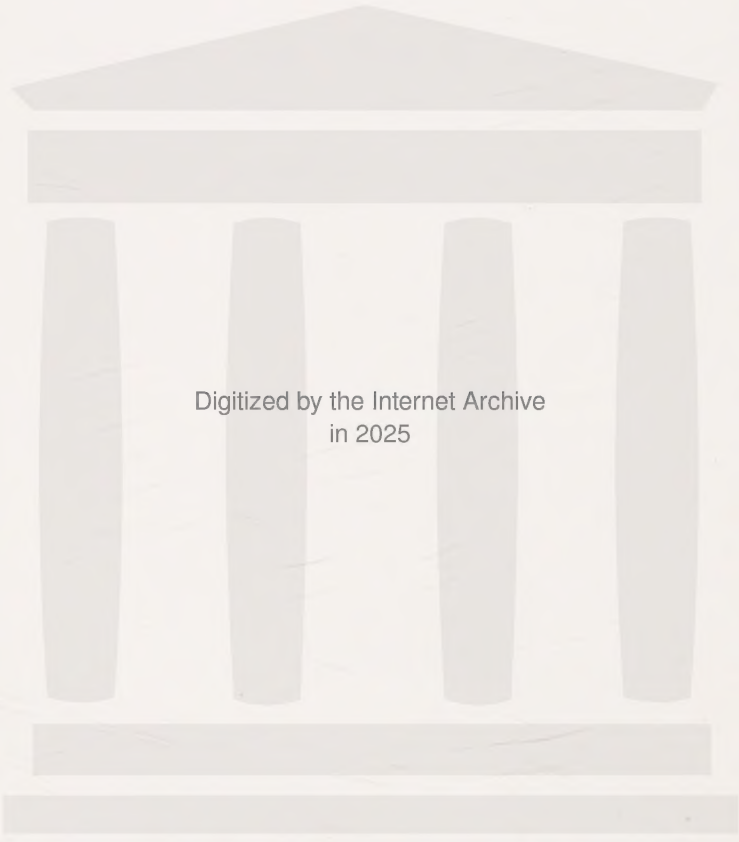
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PREFACE.

THIS is the first publication in this series of bulletins that deals with a marine biological subject. In view of the relatively greater economic value of the sea-fisheries this may appear remarkable. The reason, however, will be evident to readers who, through the medium of the Department's annual reports and previously published bulletins, have followed the progress of fishery research in the Dominion over the first few years of its infancy.

The fresh-water fisheries of New Zealand are a subject of ardent interest to many anglers, both residents and visitors from overseas, and the maintenance of their standard of excellence has been a matter of concern to most members of that great body of sportsmen who depend on our numerous rivers and lakes for their favourite recreation. Thus it came about that the first organized scheme for fresh-water biological research was initiated by acclimatization societies and was directed upon the study of conditions connected with the well-being of trout stocks in New Zealand waters. By assisting in the direction of the investigations and in the publication of results, the Marine Department has throughout collaborated in this work; and now that it is directly responsible for the further prosecution of fresh-water research it depends for financial provision on a 10-per-cent. levy from trout-fishing-license fees.

The establishment of a departmental fisheries laboratory in Wellington in 1937 was primarily to meet the requirements of fresh-water work, but fortunately it was possible also to include accommodation there for the Marine Biologist and to make provision for the modest facilities which enabled the writer of this report to carry on his work. We still lack the highly specialized equipment which has been developed for sea-fishery and associated marine biological investigations since the beginning of this century in the great fishing centres of the Northern Hemisphere, and more recently by the Council of Scientific and Industrial Research in the Commonwealth of Australia. The requirements of war have unfortunately now deprived the Department for the time being of the use of the recently built "Ikatere," which would have enabled us to make a much desired improvement in the intensity and efficiency of our investigational work out on the fishing-grounds. It will be seen from the perusal of Mr. Rapson's report that comparatively simple and inexpensive equipment has been used for his investigations, and that, in providing for the Marine Biologist's work at sea, the co-operation of commercial fishermen has been essential. For their assistance to the Department by accommodating workers on their fishing-boats and by helping in various other ways we would like to express our appreciation and thanks.

That there are problems connected with the proper control and conservation of our sea-fisheries, and that such problems must be solved before an enlightened policy of fisheries administration can be undertaken, has not received such general recognition as has the case for fresh-water research. This is probably because even the more obvious manifestations of life in our seas are only partially and imperfectly understood. It is not many years since the general public, and even those who professed to speak

with some knowledge and authority, regarded the vast expanse of ocean around these islands and entertained the idea that the supplies of sea-fishes were similarly vast and that the feeble operations of man as practised in New Zealand were not likely to make any very appreciable impression on supplies provided by a bounteous Nature. There will be few who entertain such ideas at the present time, although our elucidation of the factors controlling the natural supply of fish has not proceeded very far. I may here quote from my report on fisheries for the year ended 31st March, 1937, where, in referring to the acquisition of the Fisheries Laboratory, I gave an outline of the problems that awaited investigation. I pointed out that—

"Science as applied to the art of fish conservation consists mainly of the study of the factors that may be classed as favourable or inimical as they affect the existence of any particular species of useful fish. Common experience has shown that, so far as our commercial New Zealand fishes are concerned, they were more abundant in the earlier days—even so recently as under twenty years ago—than they are to-day, and that fishery operations are the new factors that have come into play to account for the reduction. The systematic or scientific study of the effects of the human factor upon fish-life is therefore an important part of fishery investigation; and fishery statistics are the means whereby this line of investigation is carried on. But having, by statistical or other methods, reached the conclusion that a certain fishery is in need of regulation—which usually implies restrictions—the question arises as to the most suitable form of restriction to apply. The most suitable form is what will give the greatest help to the fish with the least hindrance or loss to the fishermen. It is here that a more purely biological understanding of the conditions is necessary, among which may be mentioned such matters as when and where the fish spawn, how long it takes them to mature, the size at which they mature, the rate of growth, and the rate of survival of the several generations that constitute the bulk of the stock. It is only on the basis of some knowledge of these matters that intelligent control of fishery operations can be attempted. With no immediate prospect of pursuing fishery research on an extensive scale, it is on these lines that our inquiries should be directed, and on these lines, with the understanding assistance of members of the fishing industry, it is possible to make progress with the modest material equipment that is within the scope of reasonable financial resources so long as staff is available; for it is a specialist's job for which workers have to be qualified scientifically and for which special training is essential."

The question that will be asked by the moderately well-informed reader is, Why lead off with a report on the not very important lemon sole when there are fish of greater commercial value concerning the occurrence and life-history of which there is much-needed light to be thrown? The following explanation gives the reason.

With numerous problems requiring attention, regarding not only food-fishes proper, but also molluscs such as toheroa and oysters and crustaceans such as crayfish, it has been necessary to economize by localizing the work as far as possible. Moreover, a conspicuous case of the problem of depletion was presented by the Danish-seine fisheries of Tasman Bay and neighbouring waters just across the Strait from Wellington. These were therefore the areas in which most of the observations were made, and it so happened

that among the data collected those relating to the species *Pelotretis flavilatus*, commercially known as the lemon sole, appeared to offer the most comprehensive and satisfactory evidence for a report which, although not so complete or conclusive as must eventually be attained, nevertheless throws light on some of the fundamental questions that require to be elucidated by research for the guidance of fishery administration. It also illustrates various methods used in collecting the requisite material for study with the means available to a single-handed biologist.

Mr. Rapson has summarized and supplemented the previously published information regarding the anatomical characters by which the species is identified and has then proceeded to establish the identity of eggs and larval stages taken by tow-netting in order that the time and place of spawning might be determined and the first stages of the lemon sole's life-history might be known. This early stage, when the pelagic eggs and larvæ are carried willy-nilly with the mass of water into which they are shed by the parent fish, constitutes a very critical phase of a fish's life. Favourable conditions make for a higher rate of survival (though mortality is exceedingly high even under optimum conditions), and unfavourable conditions make for a decline in the normal abundance of the stock derived from that spawning. The fisheries depending upon the catches of this generation when it reaches marketable size will thus be affected for better or worse by purely natural causes, the factors of which are both physical (including at least the temperature and movement of the water) and biological (concerning the occurrence of predators which destroy, or of organisms necessary for the nourishment of the minute fish-fry upon the presence of which their survival depends). The rest of the report treats of the later phases of life, including such points as the determination of the age of individual fish, and the statistical utilization of length-measurement data as a basis for the study of the vital statistics of the stock. The data on this species constitute part of a mass of information obtained from fishing and plankton-collecting voyages. There are inevitable gaps in the evidence collected, and therefore a certain tentativeness about some of the conclusions.

It is considered that the publication of this contribution from the Department's Marine Biologist is timely not only because it presents recently ascertained scientific facts regarding the species, but also because it illustrates the methods that are being applied to the investigation of other species of both flat and round fish of principal commercial importance.

A. E. Hefford,
Chief Inspector of Fisheries
and Director of Fishery Research.

Wellington, 23rd May, 1940.

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The Reproduction, Growth, and Distribution of the Lemon Soles (*Pelotretis flavilatus* Waite) of Tasman Bay and Marlborough Sounds.

By A. M. RAPSON, M.Sc.,
Marine Biologist, Fisheries Branch, Marine Department.

INTRODUCTION (PREVIOUS WORK).

THE most noteworthy contribution to our knowledge of the flat fishes is to be found in the record of the trawling expeditions carried out by the New Zealand Government. Four surveys were made in the years 1900 to 1907. In 1900 and 1901 the steam trawler "Doto" fitted with otter trawling gear was used, and in 1907 the "Nora Niven," which had just been delivered from England, was chartered.

The principal aim of the surveys was to prospect for suitable trawling-grounds in order to aid the fishing industry, and as a result a considerable amount of detailed knowledge of the location of fishing-grounds and the distribution of various species was obtained. An important result of the final survey of the "Nora Niven" is the account of the fishes by Waite (1911). In the section on Pleuronectidæ he describes the genus *Pelotretis* as new and gives the following description of the single species *P. flavilatus*:—

B. vii.; D. 89; A. 71; V. dex 7, sin. 5; P. dex. 12, sin. 11; C. 13 + 4; L. lat. 78; L. tr. 26 + 39; Vert. 11 + 31 = 42.

Length of head, 4·8; height of body, 1·8; length of caudal, 5·0 in the length; diameter of eye, 3·9 in the head. The eyes are large, crowded to the front of the head, and the upper one is close to the dorsal edge, which is incised so that the eye can be seen from the under side: lower eye slightly advanced, a small knob in front of it; this eye is separated from the maxilla by a narrow ridge only.

Teeth.—Present on the blind side only.

Fins.—The dorsal fin begins above the front edge of the eye and none of the rays is entirely free; the longest rays are about the middle of the fin and are 2·2 in the length of the head, the rays are slightly sheathed, the sheath being more extensive on the right side: the anal is similar to the dorsal and is coterminal

with it: the right ventral is but slightly separated from the anal; the left is small, a little longer than the eye; it covers the vent, which is behind its base: the right pectoral is longer than the left, 1·5 in the head, both are strongly rounded: the caudal is slightly rounded, and the depth of the peduncle is 4·5 in that of the body.

Scales.—Ctenoid on the right side, entire but striated on the left, the lips and the proventral on the blind side are naked, otherwise the whole head is scaly, the scales being imbricate; they clothe the fin rays also, the ventrals and anterior rays of the dorsal and anal excepted.

Colours.—Grey or brown above, both body and fins with irregular though well-defined markings, sometimes absent; underside yellow.

Length.—311 mm.

Waite's drawing of the lemon sole, printed in the Records of the Canterbury Museum, is reproduced in Fig. 1. Referring to the distribution, Waite states that the species was taken throughout the cruise of the "Nora Niven," including the Chatham Islands and at all depths from 9½ fathoms to 50 fathoms.

More recent data are given by Norman (1926) from an examination of three specimens 225–230 mm. in length.

D. 83–91, A. 70–75, P. dex. et sin. 11–13. C. 2/14/2. V. dex. 7 (joined to anal) sin. 5–6. Depth of caudal peduncle 1⅓–1½ times length of head. Scales of ocular side more strongly denticulated than those of blind side, some of which may be quite smooth, 77–85 scales in longitudinal series just above lateral line, 28–30 between lateral line and highest point of dorsal profile. The habitat is limited to New Zealand and the Chatham Islands.

A valuable record of the early development is that given by Thomson and Anderton (1921). In 1905 these men obtained eggs of the lemon sole and were able to study the development for eight days after the larvæ hatched. Figures of both eggs and larvæ are given. Unfortunately, at the time when eggs were obtained the liberation of larvæ in the sea was considered of more importance than a study of the early stages, so the section of the work describing the development and characteristics of the larvæ is rather fragmentary.

An important note referring to age and growth of the lemon sole is to be found in the report by G. M. Thomson on the Marine Fisheries Investigation Station at Portobello for the year 1927–28.* An extract from a report by H. K. Finlay states that scales of the lemon sole, among other flat fish, are difficult, if not impossible, to read with ordinary methods available. The otoliths, however, Dr. Finlay finds, give much more satisfactory results.

* Report on fisheries for year ended 31st March, 1928, p. 17.

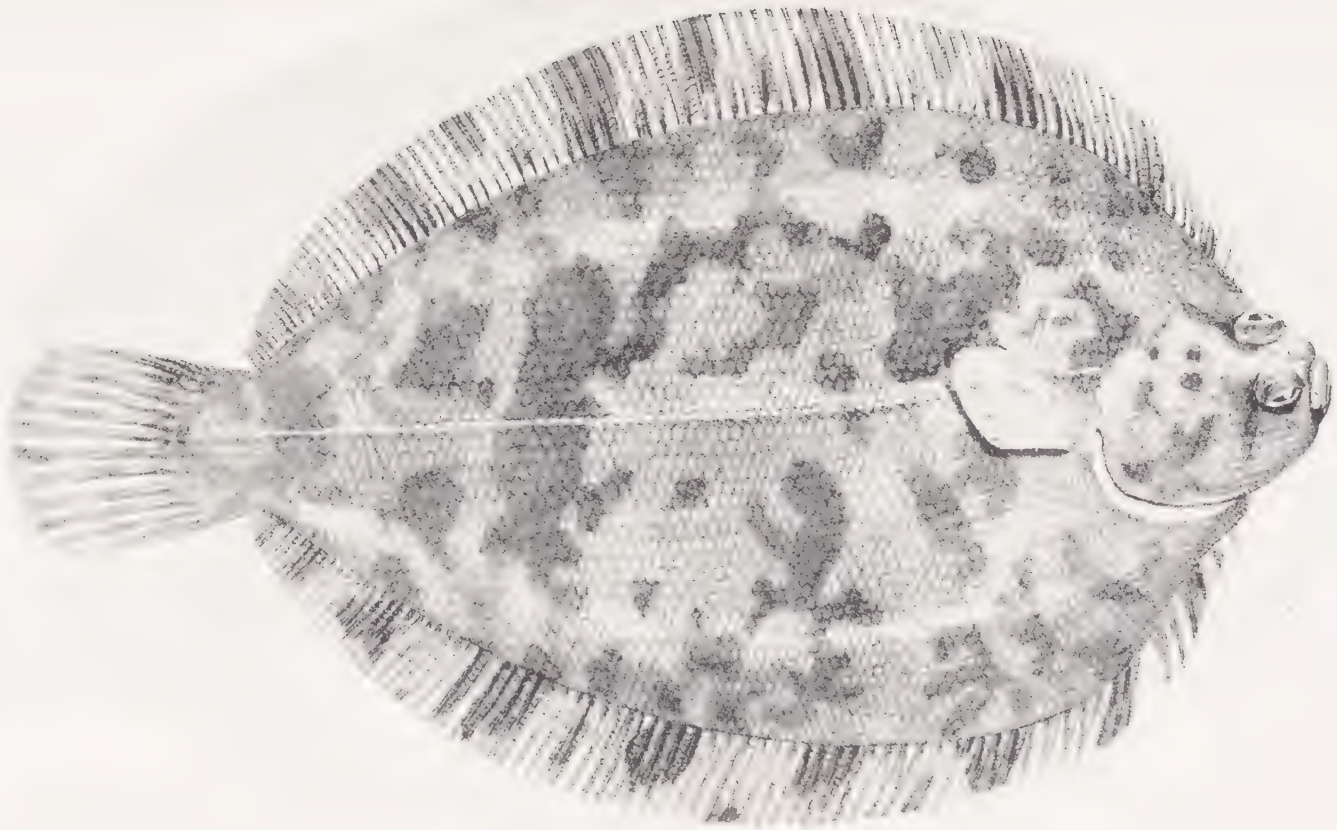


FIG. 1.—Waite's drawing of the lemon sole, reproduced from the "Records of the Canterbury Museum," Vol. 1, No. 3.

COLLECTION OF MATERIAL.

Material for the present work has been collected since 1934. The measurements and observations on the fish were made from Danish-seine fishing-boats operating from Nelson in 1934 and 1935. Either the whole catch or a fraction of it was measured, so that in all cases the fish measured are representative of commercial catches. The collection of otoliths is far too small to be considered as establishing the last word on the growth of the lemon sole. However, they give some idea of the range in size of the various age-groups, the rate of growth, and the age at which maturity is reached. For a report of this type which of necessity covers many aspects of fishery research, this small collection has produced better results than were ever anticipated.

As a continuation of the Danish-seining work, the collection was made from 1936 to 1939 of a series of tow-nettings to determine the distribution of eggs and larvæ. The work was done with two

Fig. 2.—The Danish-seine boat "Spray" fishing off Kaitere.

tow-nets of bolting silk, one 18 in. diameter, 6 ft. long, and having 70 meshes per inch; the second 36 in. diameter, 10 ft. long, and with 28 meshes per inch. As most of the collections were made from a 28 ft. launch, the handling of a 36 in. net might have provided some difficulties. However, constructing the net so that the ring could be folded in two proved extremely convenient, particularly so in windy weather, when a large ring net is difficult to handle. A bridle of four ropes prevented any serious trouble arising from the net closing while in operation. Figures 3 and 4 show the net open and folded in half. Tows were made of ten minutes' duration.

By artificial fertilization eggs at various stages of development and larvæ, until the yolk was absorbed, were obtained. This series has been used in the identification of eggs and larvæ taken in the tow-nets.

TREATMENT OF DATA.

In order to analyse the measurements of fish the fishing-grounds have been divided into ten areas shown in Fig. 5. Some of the divisions were made because of obvious differences in the fishing-grounds—for example, fish from the spawning-grounds could readily be distinguished from those taken in shallow water; other divisions, however, are more arbitrary.

FIG. 3.—The 36 in. tow-net half-closed.

A considerable number of tables has been included as it is considered that differences in the stocks of fish can be discovered only by such a detailed analysis. By the examination of a large number of fish also, important facts concerning their distribution, size at maturity, and spawning-habits can be discovered.

In the tables measurements of the fish are given to the complete centimetre below the total length—thus 28·0 and 28·9 cm. are recorded at 28 cm. and when averages have been made 0·5 cm. has been added.

A preliminary sorting of the plankton from the coarse-meshed net was made, if the weather permitted, as soon after collecting as possible. The larvæ, it was found, are too easily damaged when preserved with other plankton.

Although flat-fish larvæ were obtained at quite an early stage of the work it was necessary to collect for a period of two years

Fig. 4.—The 36 in. tow-net folded in half indicating ease in handling and small size for stowing.

before a sound identification of all stages could be made. The reason for this is that no previous records of the post-larval stages of *Pleuronectidae* in New Zealand waters exist and it was necessary to collect an extensive series before any attempt at a classification of larval stages was made.

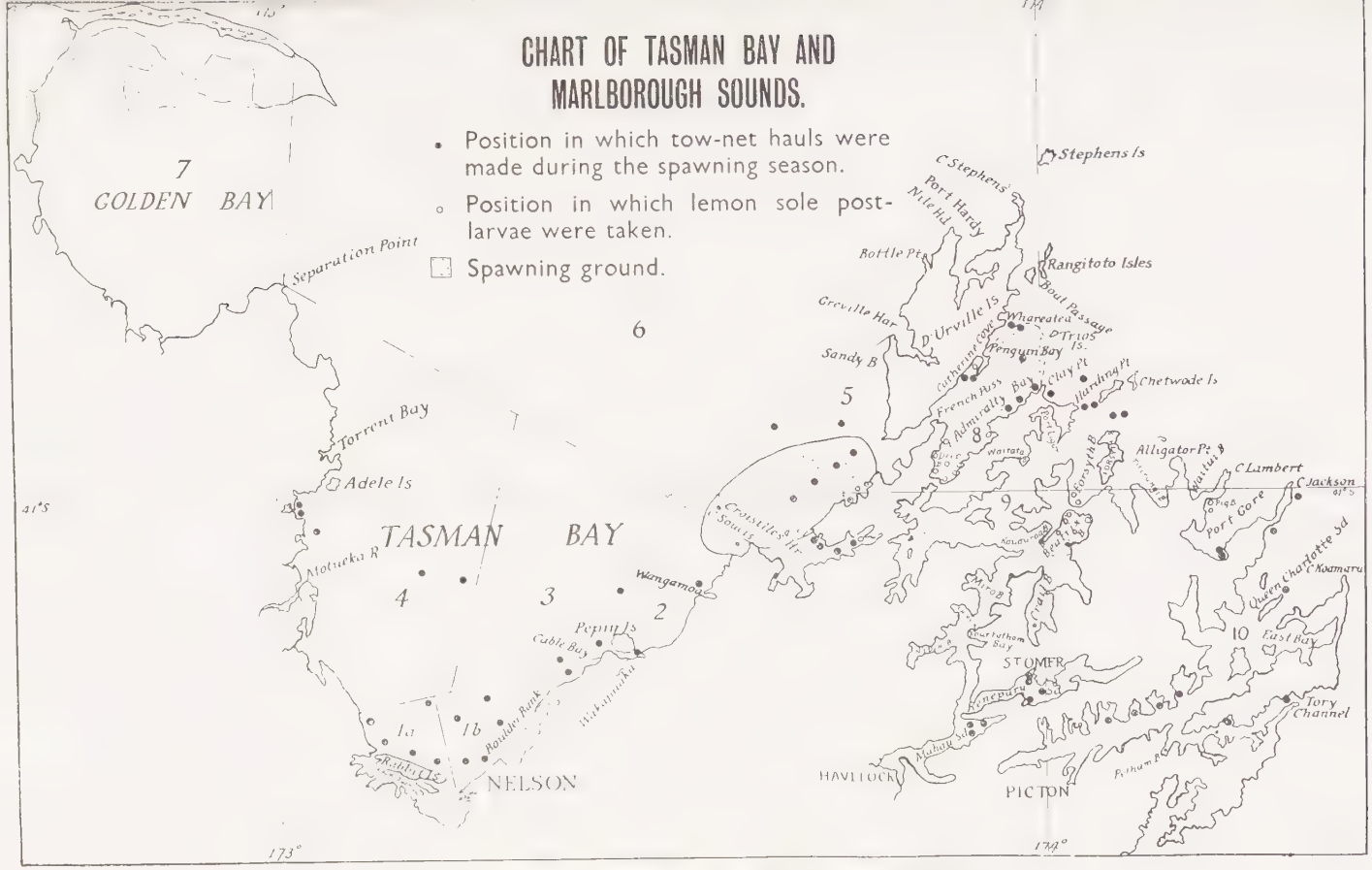


FIG. 5.—Chart of Tasman Bay and Marlborough Sounds.

DESCRIPTION OF ADULT FISH.

In the identification of the post-larvæ taken in the tow-nets it was found that some possessed more fin rays in the dorsal fin than had previously been described in any specimen. As there was a possibility that these larvæ were of a different genus an examination of a number of characteristics of sixteen lemon soles ranging from 230 mm. to 365 mm. in length, was made. Some were collected from each of the three main localities—off the Croisilles, Admiralty Bay, and Pelorus Sound.

Dorsal Fin.		Pectoral Fin.		Anal Fin.		Ventral Fin.	
Number of Fin Rays.	Number of Fish.	Number of Fin Rays.	Number of Fish.	Number of Fin Rays.	Number of Fish.	Number of Fin Rays.	Number of Fish.
		Dextral.				*Dextral.*	
83	3	10	2	67	3	6	2
84	..	11	5	68	..	7	14
85	1	12	6	69	4		
86	3	13	2	70	1	*Sinistral.*	
87	2	14	1	71	2	4	2
88	..			72	4	5	14
89	1	*Sinistral.*		73	2		
90	2	10	6	74	2	Vertebrae.	
91	2	11	3			Number of Vertebrae.	Number of Fish.
92	..	12	5				
93	2	13	2			39	2
94	2					40	9
						41	4

No distinguishing characters were found by which the fish from one locality could be said to differ from the others. Characters of three lemon soles examined from the Hauraki Gulf, however, indicate that a very considerable variation in the number of fin rays is possible. In the dorsal fin the number of fin rays in the three fish varied from 74 to 83, and in the anal fin from 60 to 67.

In the living fish the dorsal surface has a distinct yellowish colour which may vary from greyish to brownish yellow. Admiralty Bay fish were found to be for the most part of a single shade of colour, Pelorus Sound and Tasman Bay fish not infrequently were mottled as Waite's drawing indicates (Fig. 1). There is a scarcity of black chromatophores. The underside is white or pale yellow.

In the female the oviducts open to the exterior on the blind side, just posterior to the anus. In the male the sperm duct opens to the exterior on the pigmented surface immediately posterior to the urinary duct. The female, however, can be readily distinguished from the male as the ovaries extend backwards from the posterior part of the body cavity for a distance at least one-third the total length of the fish, while in the male the gonad extends similarly not more than one-eighth the total length of the fish.

DEVELOPMENT.

The egg is pelagic, quite transparent, and no markings of any sort were found on the egg membrane. There is a narrow perivitelline space, and the yolk contains from 4 to 16 oil globules, usually scattered evenly over the surface, but they may form a compact mass at the vegetative pole. The following table gives the variation in size of artificially fertilized eggs and a similar series of naturally fertilized eggs taken in the tow-nets; both series were obtained in 1936:—

Total Diameter, in Millimetres.	Artificially-fertilized Eggs.	Eggs from Tow-nets.
0·83	4	6
0·86	26	25
0·89	18	38
0·92	18	13
0·95	4	1
0·98	4	..
Total number	74	83

The average size of artifically fertilized eggs is 0·89 mm. and of eggs from tow-nets 0·88 mm. Thomson, G. M. (1921), records the size as "about 0·80 mm.," but gives no range in size, which, however, is known to vary considerably from year to year in a number of species of fish (Thomson, W. F., and Van Cleve, 1936).

The size of the oil globules varies from 0·06 mm. to 0·12 mm. There is no obvious relation between the size of the egg, the number, and the volume of the oil globules; usually, however, when a large number is present the average size is smaller than when there are only a few. The volume of oil globules in a few eggs varied between one-fiftieth and one-hundredth of the total volume of the egg.

In the living egg the perivitelline space is small, but when preserved in formalin it becomes enlarged due to the shrinkage of the yolk. This gives the preserved egg at some stages of development—notably before the closure of the blastopore—quite a different appearance from normal.

Development took place for the first sixty-six hours at 8° to 9° C., and afterwards at 13° to 14° C.

After fertilization the protoplasmic part of the egg passes to the animal pole, and by a very slight latitudinal constriction becomes marked off from the yolk. The oil globules, if they are scattered, pass usually to the vegetable pole. The first cleavages are quite regular and typical of teleost development so that at the sixteen cell stage the blastodise forms a cap over the animal pole of the egg. On the third day after fertilization both black and yellow pigments appear. The black pigment is in the form of minute granules, the yellow is lodged in chromatophores and is quite a characteristic feature. The tail and body of the larvæ at the time of hatching do not completely surround the yolk. Figure 6 is typical of the embryo at this stage.

The larva hatched four days (95 hours) after fertilization. There is a marked flexure of the embryo caused by the anterior part of the body curving over the yolk; but this disappears in a few hours due partly to the straightening of the larva and partly to the growth of the optic lobes both forwards and upwards.

At the time of hatching the larva presents a striking appearance with the large masses of yellow pigment spots interspersed with many more minute granules of black pigment. For the first three days they remain suspended in the water with the tail and yolk uppermost, and any movements are without directive effort. Figure 7 shows the distribution of the black pigment. On the fourth day after hatching the retinal pigment of the eye develops as a heavy black layer. By this time the pectoral fins, which in the newly hatched larva are represented by horizontal ridges in the body wall, are extremely well developed and are used in swimming. No trace of fin rays, however, has appeared in any of the fins. The following table gives the average size of the larvæ up to the fifth day after hatching, after which no appreciable growth took place:—

	Just hatched.	One Day.	Two Days.	Three Days.	Four Days.	Five Days.
Average length of larvæ, in mm.	2·1	2·3	2·5	2·5	2·6	2·8

IDENTIFICATION OF EGGS, LARVÆ, AND POST-LARVÆ TAKEN IN THE TOW-NETS.

1. The Eggs.

The characteristics of the egg described on page 17 are sufficient to identify any lemon-sole egg taken in the tow-nets. Two other types of eggs with more than one oil globule occur in the tow-nettings, but these are quite dissimilar from the lemon-sole egg.

The first type is of the *Rhombosolea* species. These eggs vary from 0·57 mm. to 0·71 mm. in diameter and have from 5 to 13 oil globules. Their small size alone distinguishes them from the lemon-sole eggs.

The second type is a very small egg 0·45 mm. to 0·50 mm. in diameter with from 2 to 6 small oil globules. This egg agrees with the description given by Thomson and Anderton (1921) of the egg of the common sole *Peltorhampus novæ-zeelandiæ*. The remaining eggs taken in the tow-nets possessed one or two oil globules or no oil globule at all.

2. The Larvæ and Post-larvæ.

For convenience of description the series of larvæ collected has been divided into a number of stages in which the change from larval to adult form can readily be followed; there is in all stages a certain amount of overlapping:—

Stage 1 (Fig. 7).—Larval pigmentation of minute black pigment spots: 25–28 muscle segments; length, 1·9 mm. to 2·8 mm.

FIG. 6.—Egg of the lemon sole with embryo shortly before hatching.

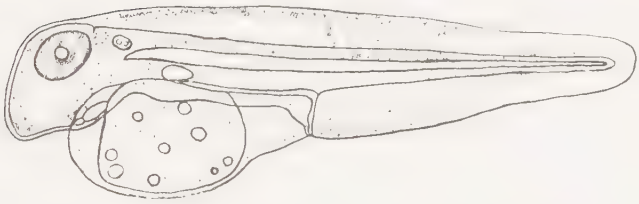


FIG. 7.—Larva, stage 1, shortly after hatching, showing distribution of black and yellow pigment. Yellow pigment shown faintly stippled.

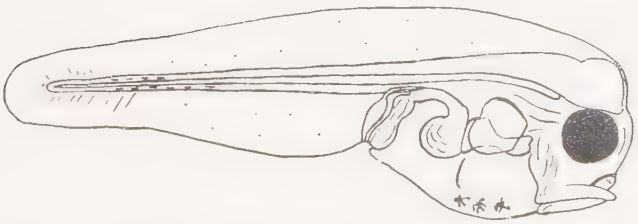


FIG. 8.—Post-larva, stage 2, shortly after the yolk-sac was absorbed, showing first development of post-larval pigment.

Stage 2 (Fig. 8).—Larval pigment still present on fins, but first development of post-larval pigment appears at this stage as a dorsal and ventral band of pigment on each side of the dorsal and anal fins. Below the gut also a few large black chromatophores appear. These two characteristics are a constant feature of the post-larva until the adult pigmentation appears. The fins are still in the larval condition, and no fully-developed fin rays are to be found. Approximately 30 muscle segments; length, 2·4 mm. to 4·0 mm.

Stage 3 (Figs. 9 and 10).—Larval pigment practically disappeared, and, in addition to the pigment bands present at stage 2, two further rows, which do not extend so far forward as those in the previous stage, develop just dorsal to the notochord. Post-

Fig. 9.—Post-larva, early stage 3, showing development of post-larval pigment.

larvæ are still symmetrical. Caudal fin with up to 11 rays developed, dorsal fin up to 88 rays, anal fin up to 53 rays. About 35 segments; length, 3·9 mm. to 4·3 mm.

Stage 4 (Fig. 11).—Development of fin rays well advanced; caudal fin 15 or 16 rays, dorsal fin up to 93 rays, anal fin up to 59 rays. Post-larva still transparent, but not symmetrical. The left eye has moved towards the dorsal surface of the head.

Stage 5 (Fig. 12).—At this stage the shape of the young fish is apparent. In addition to the pigment bands previously described, other pigment characteristic of the adult begins to make its appearance and gradually obscures the bands of black pigment.

Practically all the larvæ collected belonged to stages 2, 3, and 4.

DISTRIBUTION OF EGGS AND LARVAL STAGES.

1. Distribution of Eggs.

At the commencement of the work in 1936 the collection of tow-nettings was extended over as large an area as possible in an attempt to locate other spawning-grounds than those where spawning

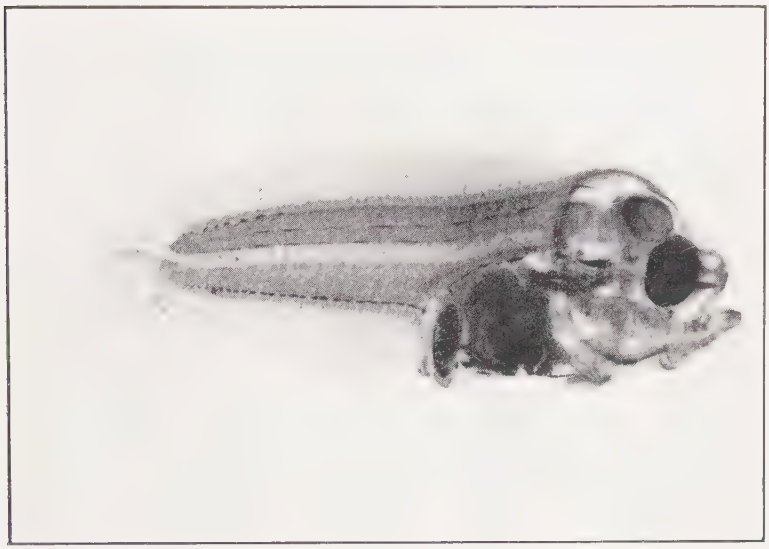


Fig. 10.—Post-larva, later stage 3, showing further development of post-larval pigment.

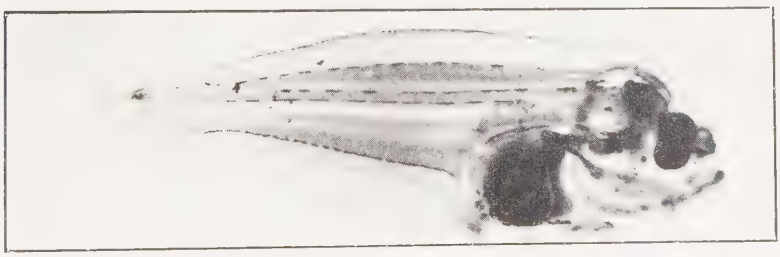


Fig. 11.—Post-larva, stage 4.

[*Photo by K. Ross.*

fish were taken in the Danish seine. No new spawning-grounds were definitely located, however, but a considerable amount of negative evidence in the form of tow-net samples barren of lemon-sole eggs has been collected.

The disadvantage of extending the work over a large area is that the exact limits of a spawning-ground cannot be defined. An exact determination of a spawning-ground for any particular period would serve no practical purpose as the schools of spawning fish move about considerably, and in Tasman Bay at least their position may vary by ten miles or more from one season to the next, and by several miles from day to day.

A record of the tow-nettings until June, 1939, which contained lemon-sole eggs is given in Table 11.

Continuous observations on the spawning could not be made, but each year several months were spent on the spawning-grounds so that over a period of five years a considerable amount of data has been collected. In 1935 spawning fish were taken both in

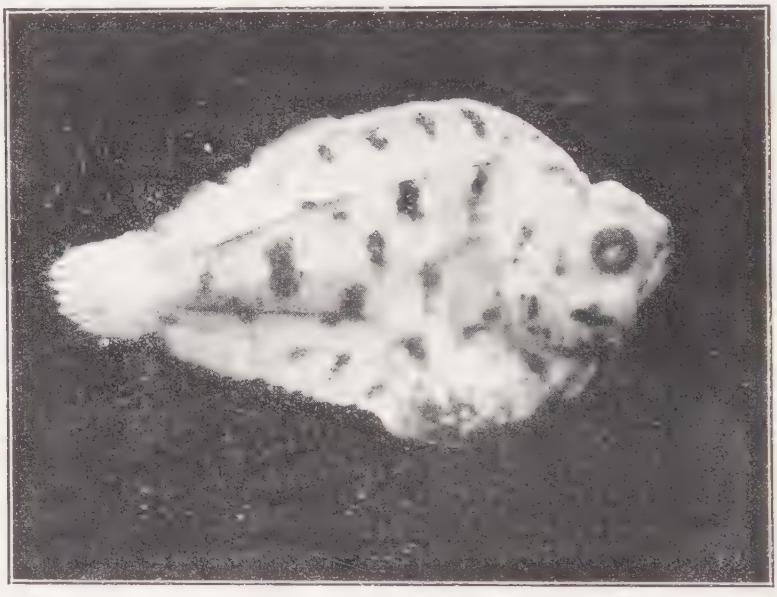


FIG. 12—Post-larvæ, stage 5.

[*Photo by K. Ross.*

Admiralty Bay and off Croisilles Harbour in July, and in 1936 eggs were taken in the tow-nets in these localities from July to September. In September the number of eggs taken was considerably less than in the previous months, and from the evidence of the number of eggs present spawning continued in Tasman Bay until December, when, however, it had ceased in Admiralty Bay and Pelorus Sound.

In 1937 spawning was taking place early in June both in Admiralty Bay and Pelorus Sound; it was not possible to fish in Tasman Bay in June. During July and August, 1937, no great numbers of eggs were taken, but the distribution was much more even and over a larger area than was found in the previous year.

The collection of tow-nettings in 1938 was extended along the west coast of D'Urville Island as far as Port Hardy at the northern end of the island. A few eggs were taken in all hauls made, and in the region of Port Hardy it is probable that a small amount of spawning takes place. The bottom, however, is mostly foul ground in Port Hardy, and, although good catches of large lemon soles were reported in August, 1938, no very extensive seining operations have ever been carried out. The presence of large lemon soles in Port Hardy during the spawning-season may probably be considered further evidence that the species migrates from deep water to spawn.

At the end of June, 1939, spawning had not commenced in Admiralty Bay.

Available data on the period during which spawning occurs may be summarized:—Spawning extends over a period of about six months; the season usually commences in June and may continue until December; the most important spawning month is August.

Lemon-sole eggs are extremely buoyant, and when left in a jar of sea-water they form in a few seconds a dense layer at the top. Despite the extreme buoyancy, however, considerable numbers were taken in tow-net hauls made at or near the bottom. Eggs taken in bottom hauls contained similar developmental stages to those in hauls made at the surface, so the eggs in bottom hauls were not newly spawned. One reason that so many eggs were taken in bottom and mid-water hauls is that in making a haul in, say, 30 fathoms of water the vertical distance travelled by the net is nearly one-quarter the total distance the net is towed. (The net was allowed to sink to the bottom by the weight of the sinker before towing started.) Another reason that eggs are present at the bottom is that tidal currents throughout the whole region are strong; at times they appear sufficiently rapid in some places to produce a mixing of waters which would make a tolerably even vertical distribution of the eggs.

An examination of the data in Table 11 shows that there are three important centres of distribution of eggs. They are:—

(1) Off Croisilles Harbour (Tasman Bay).
(2) Admiralty Bay.
(3) Beatrix Bay (Pelorus Sound).

In Cook Strait the tidal current not infrequently is quite irregular, and in the event of an unusual disturbance on some part of the coast it may flow in the same direction for eight, ten, or even twelve hours. Several upsets like this, if they occurred during the height of the spawning-season, might result in the removal of a great quantity of eggs from their normal position.

Hickling (1935) showed that the stock of hake on the west coast of Ireland was largely determined by two factors—(1) the drift of surface water, and (2) the temperature of the surface water.

The following table gives the drift of the surface water from 1930 to 1933. The observations used are from the Stephens Island Lighthouse, and the surface drift of the water, calculated as one-twentieth (Hickling) of the distance travelled by the wind, as calculated from the Beaufort scale.

Period.	Miles of Surface Drift for Period.			
	1930.	1931.	1932.	1933.
20–31 July ..	50 m. N.N.E.	109 m. E.N.E.	155 m. N.W. by N.	90 m. W.N.W.
1–10 Aug. ..	135 m. N.W.	67 m. E. by S.	78 m. N.W. ..	100 m. E.
11–20 Aug. ..	24 m. N.W. ..	165 m. E. by S.	14 m. S. ..	65 m. N. by W.
21–31 Aug. ..	45 m. N.W. by N.	25 m. E.N.E.	95 m. N.N.E.	35 m. N.W.
1–10 Sept. ..	75 m. N.N.W.	52 m. E.N.E.	65 m. E. ..	40 m. W. by N.
11–20 Sept. ..	120 m. N. by W.	42 m. W.N.W.	189 m. N.W. by N.	85 m. N. by E.

The varying surface drift in the spawning season for the years 1930–1933 may be summarized as follows:—

1930: N.W.
1931: E.
1932: N.W.
1933: N.

The considerable amount of easterly drift in 1931 is correlated with the large number of fish belonging to the age-group of fish born in 1931. Reports of fishermen in the district, too, show that in 1933 great quantities of small lemon soles were present in the commercial catches.

With regard to the potency of the easterly drift in the successful distribution of the eggs, it may be argued that the vertical distribuion of eggs disproves this idea, but the great buoyancy of the eggs mentioned previously indicates that part of the developmental period of each egg will be spent at the surface and it will then come under the influence of the drift.

Another thing to be considered is the reason for the inefficiency of other than easterly drift of water as a means to propagating the species. North-west drift in 1930 and 1932 would carry eggs from the Croisilles spawning-ground towards Golden Bay. Unfortunately, this area has never been tested for eggs, and no extensive fishing is carried out there. It is suggested, however, that as in the case of the hake (Hickling, C. F., 1935) the larvæ hatch before the eggs reach any sheltered bay on the Golden Bay coast, and perish because of the exposed position.

Flat fish in Tasman Bay and Admiralty Bay about 1930 were so plentiful and were caught in such great quantities that the supply greatly exceeded the demand for them in the Wellington market, and the wholesale price fell to about 1d. per pound. Fishing was so intense, however, that by the end of 1936 stocks had decreased and the price rose at times to over 1s. per pound.

2. Distribution of Larvæ.

Although considerable numbers of eggs were found in July, 1937, only the early larval stages were found—off the Croisilles Harbour. In the record of larvæ in Table 11 they are not recorded, as it is difficult to identify preserved specimens, and the only larvæ positively identified were found alive in the plankton

Fig. 13.—A bag of lemon soles and sand flounder taken from Penguin Bay: About 240 lb. of flat-fish valued at approximately £12 (July, 1938).

shortly after capture. Early stage 2 larvæ also were not found in large quantity because in the fine-meshed plankton net they are damaged considerably, and they are able to pass through the larger-meshed net. Late larval stages also were not found because at stage 5 (Fig. 12) the fish has practically become bottom living, so that most of the larva captured were of stages 3 and 4.

In September, 1936, after the first stage 3 larvæ had been taken in a midwater haul, a series of hauls was made with the net almost on the bottom. A towing-line equal to twice the depth of water was used; the bridle of the net was 6 ft. in length and a sinker of 18 lb. on a 10 ft. line, allowed the net to be towed approximately 3 ft. from the bottom, provided it was allowed to reach the bottom before towing was started. The method was attended with a considerable risk to the net, but the practical

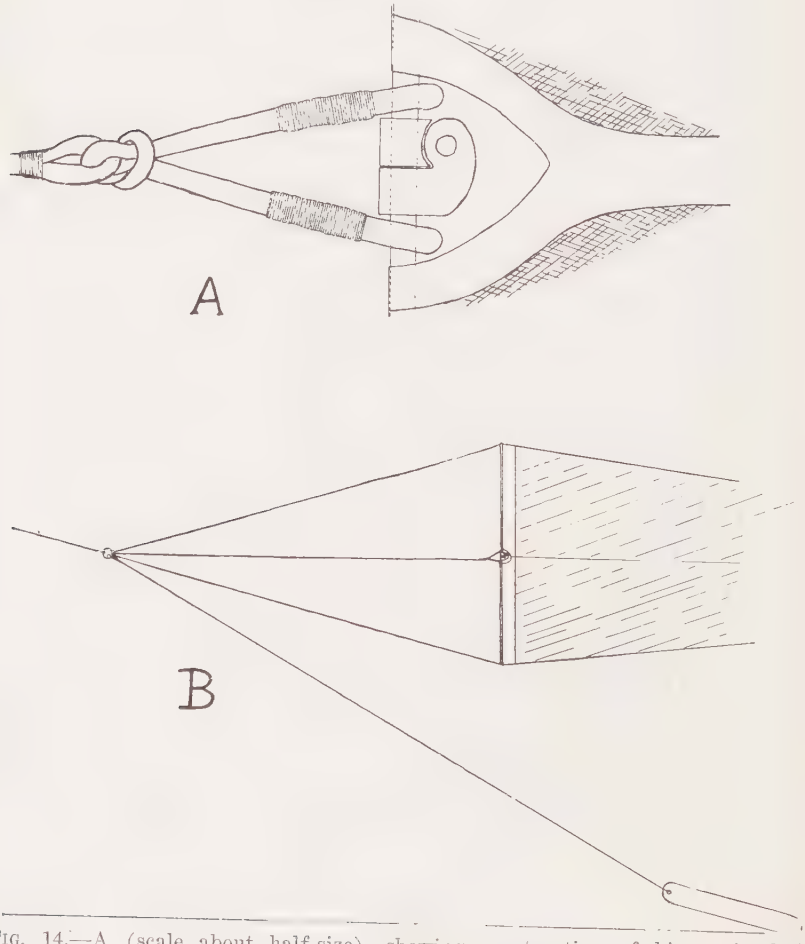


FIG. 14.—A (scale about half-size), showing construction of hinges in 36 in. diameter tow-net and method of attaching bridle rope to hinge and to ring of net. B, showing method of towing net near the bottom.

fisherman in charge of the launch is such an excellent boatman and possesses such an extensive knowledge of the coast that on no occasion up to the present time has the net been seriously damaged. The best catches of lemon-sole larvæ were taken only by towing the net in this manner although larvæ of other species including pleuronectid larvæ were occasionally taken at the surface of relatively deep and open water.

An interesting feature of the collection of larvæ is that at the end of February, 1937, ten larvæ of the 1936 spawning were collected. Larvæ were also found early in June, 1937, and although these larvæ are of the 1937 year's spawning it gives a very extensive period (nine months) during which free-swimming larvæ may be found.

The times at which larvæ and eggs are present indicates that a stage 3 larva is approximately four weeks old. The larva shown in Fig. 12 is approximately two months old; it was taken in 1936 on the 4th September.

Although many hauls were made with the tow-nets, lemon-sole larvæ were consistently present only in a very few places. It can be safely said that during the period July, 1936, to June, 1939, when eggs and larvæ were present, the east coast of Tasman Bay, Admiralty Bay, and the most important lemon-sole ground in Pelorus Sound have been well tested at some time during the spawning-season. From Table 11 it can be seen that most larvæ were found in the following places:—

(1) Port Gore.
(2) Pelorus Sound.
(3) Forsyth Bay.
(4) Admiralty Bay.
(5) East Coast, Tasman Bay (including Croisilles Harbour).

Although many hauls were made in open waters the number of larvæ taken was negligible. It is possible the method of towing was at fault; bottom, midwater, and surface hauls were made, however, towing with the current, against and across the current, at various speeds, but although other larval fishes up to 7·0 mm. in length were taken only an occasional lemon-sole larva was found. The best results for lemon soles were obtained close inshore from water 7 fathoms to 20 fathoms in depth. The occurrence of larvæ in Port Gore may be due to the easterly drift of eggs from Admiralty Bay or there may be a spawning-ground in the near vicinity as the results of the trawling of the "Nora Niven" indicate.

The presence of lemon-sole larvæ in sheltered bays close inshore and their absence off shore indicates, however, that some drift is necessary; up to the present time no factor other than a drift due to the west wind has been found.

A feature of the localities from which lemon-sole larvæ were taken is that there is practically a complete absence of fresh water entering the sea.

In three bays rather more lemon-sole larvæ than usual were taken. They are Pig Bay in Port Gore, Huritini and Rocky River Bays in Admiralty Bay, where fourteen, ten, and twenty-three larvæ respectively were taken in single hauls. These three bays have in common the fact that they are well in to the head of a deep bay where the water is deep and there is usually an absence of current. A factor, however, which may partly account for the large numbers of larvæ taken in the hauls mentioned is that in two cases the sea was much rougher than usual and in the three cases the sky was very dull.

By far the most consistent hauls of larvæ were made in Admiralty Bay, and, with the exception of a small area near the French Pass, almost all bays from Tainui Passage on the west shore to Guards Bay on the east shore have at one time yielded larvæ.

Up to the present time no other locality has been found which has produced consistently such an excellent quantity and such a variety of planktonic organisms.

DISTRIBUTION OF ADULTS.

Both the "Doto" and "Nora Niven" carried out a survey in the Foveaux Strait district. The 1900 survey was confined to the bays of Stewart Island and the southern coast of the South Island. The 1907 survey was made in the more open waters at the east end of Foveaux Strait. Only small numbers of lemon soles were caught. A few fish are recorded from Mason Bay on the east side of Stewart Island; in Foveaux Strait a single lemon sole was taken off Tewaewae Bay, and a few are also recorded from Tewaewae, Riverton, and Toitoi Bays.

Working north along the coast, the first hauls in which lemon soles are present in any quantity are found north of Dunedin. The best are recorded four miles off Blueskin Bay and five and nine miles off the Waikouaiti River. The record haul of lemon soles for the four cruises, containing 112 fish, was made twelve miles E.S.E. of Timaru; two other hauls in the vicinity gave good but much smaller results. Only mediocre catches were obtained north and north-east of Akaroa.

In Palliser Bay forty-three fish were obtained in one haul, but no great number was taken on the east coast of the North Island until north of Table Cape, where twenty-two fish were taken off Motara Island, near Tolaga Bay. Hauls made south of Poverty Bay did not yield nearly such good results.

A considerable amount of trawling was carried out in the Bay of Plenty, but the number of lemon soles taken was negligible. In the Hauraki Gulf also, although lemon soles were widely distributed, the only haul worth recording here was made from Huich Island to Cabbage Bay; twenty-one fish were taken.

North of Auckland, on the east coast, trawling was carried out as far north as Parengarenga, but no lemon soles were taken north of Whangarei. On the west coast of the North Auckland Peninsula none were taken north of Ahipara Bay, and only occasionally were any present in the hauls made between Hokianga and Kawhia Harbours.

In both the north and south Taranaki Bights lemon soles were taken in considerable numbers, and in the surveys made in both 1900 and 1907 considerable catches were made in Tasman Bay. Several good hauls were also made at the Chatham Islands.

Although a limited amount of trawling was done on the west coast of the South Island no lemon soles were taken from the part surveyed—namely, from Hokitika to Cape Farewell.

RECORD OF TRAWL HAULS MADE BY "DOTO" AND "NORA NIVEN" IN WHICH FIFTEEN OR MORE LEMON SOLES WERE TAKEN.

Date.	Haul Nos.	Number of Hauls.	Lemon Soles per Haul.	Depth (Fathoms) and Bottom.	Locality.	Centre.
9/4/1900 ..	66	1	16	9; sand	4 miles off Blueskin Bay	Blueskin Bay.
3/7/1907 ..	28–29	2	24	19–30; sand, shell ..	6 miles off Oamaru, trawling E.N.E. ..	Off Oamaru.
3/7/1907 ..	31	1	49	21–24; shell	7 miles off Waitaki River, trawling N. ..	Off Oamaru.
4/7/1907 ..	34	1	18	16–21; sand, shell ..	8 miles S. by E. off Timaru, trawling S.E. by E.	Canterbury Bight.
6/7/1907 ..	39	1	24	28–31; sand, shell ..	26 miles E. of Timaru, trawling E. ..	Canterbury Bight.
30/4/1900 ..	93	1	22	18–22	16 miles E. of Timaru	Canterbury Bight.
30/4/1900 ..	94	1	112	18–13; soft sand ..	12 miles E.S.E. of Timaru, trawling E. ..	Canterbury Bight.
13/8/1907 ..	74	1	43	20–29; F. bt. sand ..	5 miles off L. Onoke, trawling S.S.E. ..	Palliser Bay.
14/2/1901 ..	14	1	22	21–22; mud	Off Motara Island	South of Tolaga Bay.
6/2/1901 ..	43	1	21	15–7; mud	Huich Island to Cabbage Bay	Hauraki Gulf.
1–2/5/1901 ..	107–111	5	37	17–38; sand	Off Waitara	North Taranaki Bight.
4/6/1900 ..	143	1	18	14–16; coarse sand ..	6 miles S. of Waitotara R., trawling E. ..	South Taranaki Bight.
6/6/1900 ..	147	1	17	17–15; sand	5 miles W.S.W. off Turakina River, trawling S. by E.	South Taranaki Bight.
2/12/1907 ..	248	1	40	9; sand and mud ..	Guards Bay, Forsyth Island	Tasman Bay.
17–18/5/1900 ..	109–111	3	34	13–23; mud	E. side Tasman Bay	Tasman Bay.
22/5/1900 ..	122–125	4	23	5–17; sand and mud ..	Golden Bay	Tasman Bay.
1/8/1907 ..	69–70	2	18	33–45; sand and shell ..	Hanson Bay	Chatham Islands.

From the reports of the cruises of the "Doto" and the "Nora Niven" where the numbers of fish of each species are given for each haul, the table on page 29 has been made; only those hauls in which the numbers of lemon soles are fifteen or more are recorded.

Although little more can be said with certainty than that there are ten important centres of distribution it is probably not unsafe to state that at least one separate spawning-ground could be found in each. The lemon-sole eggs obtained by Thomson and Anderton at the Portobello Biological station in 1905 were probably obtained from Blueskin Bay. The three localities nearest together—Blueskin Bay, off Oamaru, and the Canterbury Bight—are fifty or sixty miles apart, and the evidence from Tasman Bay and district, where three spawning-grounds have been located within a distance of fifty miles, indicates that the number of spawning-grounds would be more than there are centres of distribution indicated in the Table.

An analysis of the depths at which lemon soles were taken in Tasman Bay showed that even in shallow water 2 fathoms or 3 fathoms deep a few lemon soles were found among other predominating species. Lemon soles taken in shallow water were usually much smaller than those from deep water, although there were exceptions. By far the greatest numbers and the largest fish were taken in water from 20 fathoms to 30 fathoms deep.

The greatest depth at which the seine net could be worked efficiently was 30 fathoms and at this depth in Area 6, Fig. 5, nine lemon soles were taken in April.

Lemon soles, however, are known to inhabit slightly deeper water than this. According to Waite (1911) they were taken from a depth of 50 fathoms, but the limit of the depth at which they live is not known. One interesting fact is that they are occasionally taken from the stomachs of hapuka (*Polyprion oxygeneios*). This is recorded by Thomson, G. M., and Anderton (1921), and has on several occasions been told the writer. One fisherman stated that he found a lemon sole still alive in a hapuka taken on a line from 180 fathoms of water.

It is a difficult matter to interpret Tables 4 and 5* in a general manner in terms of the distribution of the adult lemon soles, since the records are from the catches of a commercial fishing-boat and the fishing was carried out with preconceived ideas as to the whereabouts of the various species of fish. For this reason the tables do not give a true picture of the distribution of the adults. It may be safely stated, however, that the greatest density of distribution occurred off the Croisilles, in Admiralty Bay, and in Beatrix Bay during the months of July and August; the fish during these months are spawning.

* The measurements of fish recorded in 1934 and in January, 1935, are taken from Log Books 1 and 2 of the launch "Sweeper," a Danish-seining vessel which fished for some months under a contract to the Marine Department.

SPAWNING.

Of the fish caught in Queen Charlotte Sound* practically equal numbers of males and females were found, but of the total fish caught in all areas 30 per cent. only were males. The males tend to congregate on the spawning-grounds before the females and to remain there for a longer time. Thus in Pelorus Sound (Area 9) there were in June, 1938, 46 per cent. of males. In July and August off the Croisilles Harbour and in Admiralty Bay (Areas 5 and 8) there were respectively 36 per cent. and 34 per cent. of males and in January, 1935, when the spawning season for the previous year was over, there were 63 per cent. of males in Admiralty Bay (Area 8).

In October and November, 1934, considerable numbers of lemon soles were also present in Areas 1B and 3, and these were over 90 per cent. females. The explanation which seems most reasonable is that, after spawning, the females leave the spawning-ground and thus leave a greater proportion of males. (The percentages given above have been calculated from data in Table 5.)

As Danish-seining for lemon soles is most intensive during the spawning-season the continued presence of the males on the spawning-ground renders them more liable to capture, and their numbers have been reduced in greater proportion.

The male is smaller than the female, the average length in the total catch being 26·2 cm. for males and 28·7 cm. for females. This difference in size of male and female possibly accounts for the difference in proportion of the sexes, the net selecting the larger fish. From the body proportions of male and female, however, and the size of the mesh of the net, which was approximately of 4 in. mesh, the net efficiently catches the fish over 22 cm. in length, so, apart from a slight difference in numbers of fish above 22 cm. (caused by differences in growth rate up to this size), it is reasonable to suppose that there should normally be nearly equal numbers of the two sexes.

The only classification of ripeness of male lemon soles is given in Table 9 for fish taken in August. Sixty per cent. of these fish were milting. As in the case of the females, the number of ripe fish gradually increases until the height of the spawning-season, when a considerable proportion is found to be milting.

In Tables 6, 7, and 8 the classification of females is made into groups immature, ripening, spawning, and spent. Immature fish are those which will not spawn in the season considered. The gonads of these fish extend almost as far towards the tail as in a more mature fish, but the swelling which characterizes the gonad of a ripening fish is absent, and in some cases the position of the ovary is indicated by a slight hollow on the upper or pigmented surface. On the blind side the ovary shows as a silvery or, more rarely, as a reddish coloured stripe. The ripening female is characterized by the swelling of the gonad. Ripe eggs were easily obtained from

* As mentioned on page 37, no fishing for lemon soles had been carried out in Queen Charlotte Sound prior to the samples being taken.

spawning fish, and no eggs could be obtained from spent fish. In August eggs in many instances were extruded from the fish without any handling. Transverse sections of ovaries at three of the stages described above are given in Fig. 15.

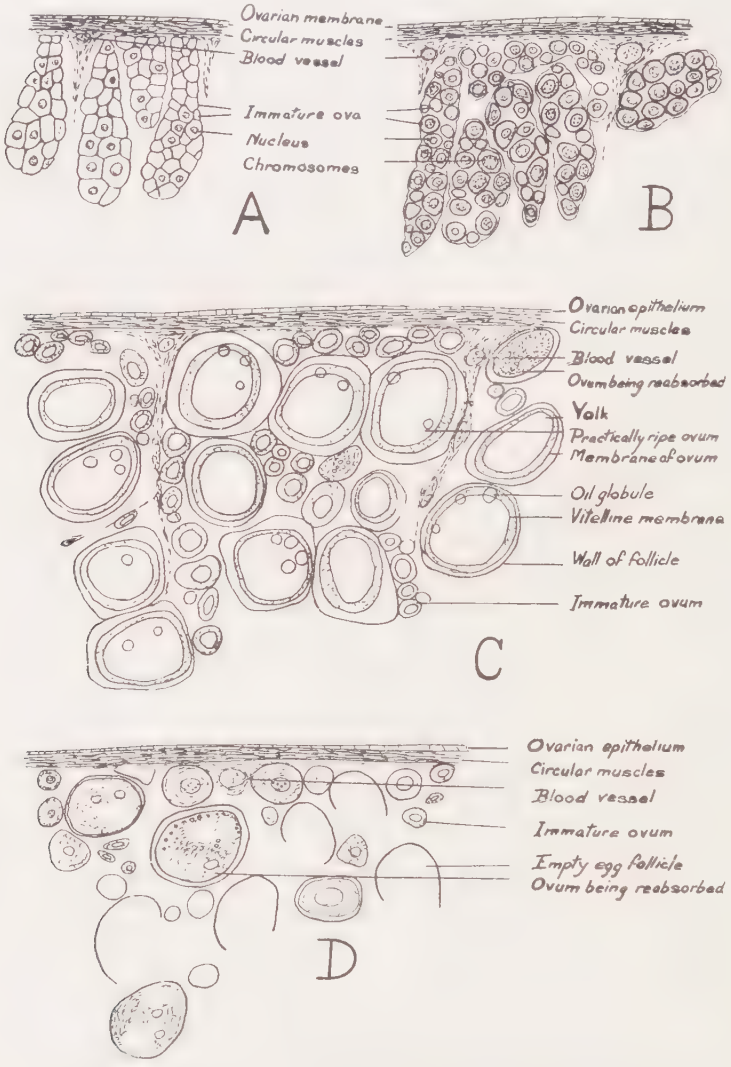


FIG. 15.—Transverse section of the ovaries of lemon soles (x 12)—A, 20 cm. fish; B, 23 cm. fish (both immature fish which it is considered will not spawn in the season studied); C, fish almost ready to spawn; D, spent fish.

The classification adopted is detailed, but the evidence of size and age at maturity and the number of fish spawning at one time are all of practical importance in deciding upon a close season for fishing. For an accurate observation on spawning it

is also necessary to state the exact locality of the fishing-ground, as even in the hundred miles of coast-line studied slight differences in the time of spawning have been noticed.

The scarcity of immature female fish is remarkable (Tables 6–8). In June, July, and August they are classed as 18, 6, and 1 per cent. respectively, the differences in number being accounted for by the fact that in June and July non-spawning grounds were included in the totals. In the month of June a classification is given for only one locality (a non-spawning ground), but no spawning or spent fish were found in any place fished during this month.

Referring to the data on the age and growth of the fish it is evident that most fish become mature and spawn during their second year, and it is due to the early age at which the fish mature that there are so few immature fish in the commercial catches.

Another important fact shown by the tables is that the larger fish spawn before the smaller. In July (Table 7) most of the spawning and all the spent fish were over 30 cm. in length, but at the end of August, when spawning was at its height, fish at practically every size were spawning freely (Table 8). Of the fish taken on the spawning-ground in August less than 1 per cent. would not spawn before the end of the spawning-season. The fact that small young fish spawn is important, and the continued existence of the fishery is to a large extent due to the small size at which the fish mature.

From a ripe female fish only a small number of eggs (some thousands) can be obtained on stripping, and there are more fish spawning in the afternoon than in the morning, a fact also observed by Thomson, G. M., and Anderton (1921). From the small number of eggs spawned at one time compared with the total number of eggs in the ovary, it seems that spawning must extend over a period of days. Meek (1924) describes a similar state of affairs in the cod *Gadus callarias*. The locality in which the greatest intensity of spawning occurred was between Clay Point and Penguin Bay, where 65 per cent. of the females were spawning freely.

One interesting feature of the spawning-ground in Beatrix Bay in Pelorus Sound is that although eggs and larvæ were taken in the tow-nets the result of spawning has never appeared to be very satisfactory. From observations on the fish in 1935, 1936, and 1937 spawning on this ground did not seem to be at all on the same scale as in other places, and from ripe fish a much smaller number of ripe eggs could be obtained than in the more exposed spawning-grounds. In the ovaries of a number of fish examined, the yolks of the eggs had taken on a granular appearance, and shrinkage prevented the yolk from completely filling the egg. These eggs are similar to unspawned eggs in the ovary of a spent fish, and were being reabsorbed.

The reason for the non-spawning of some fish may be the confined nature of Beatrix Bay and possibly also the fact that at times a considerable volume of fresh water enters Pelorus Sound.

In 1935 the Danish-seine fishing in Pelorus Sound was seriously affected by the occurrence of a peculiar slime, which was present in June and July. The following table gives in concise form a record of the occurrence of the slime in three bays in the Sounds:—

Locality.	Date.	Number of Hauls.	Number of Lemon Soles per Haul.	Condition of Water.
Port Ligar ..	6/5/35	2	8	A considerable amount of suspended matter in the water; no slime.
	21/6/35	1	32	Unworkable due to heavy slime.
	19/7/35	3	58	Heavy slime.
Ketu Bay ..	9/5/35	1	60	Suspended matter not serious; no slime.
	20/6/35	1	19	Very heavy slime.
	20/7/35	2	32	Heavy slime mixed with mud.
Orchard Bay	20/6/35	2	34	Heavy slime.
	20/7/35	1	17	Unworkable due to heavy slime.

As far as the fish were concerned the slime did not appear to have affected them in the slightest, although the final settling of the slime had probably not occurred. The net, however, became coated and the meshes blocked with the slime, so that it was not only a great strain on the gear to haul it in, but, in addition, the net did not work efficiently.

Although when the slime was heaviest the surface was fairly clear, from the coating which the net received the slime must have been present at the bottom for a depth of at least 10 ft. An examination of the slime showed it to consist of rather tough practically structureless threads 4 in. to 6 in. in length and of a gelatinous consistency. The term "slime" is possibly not entirely correct for these threads, as although they appeared slimy they were rather firm to the touch. The firmness may have been due to the presence of a small amount of fine silt adhering to the threads. The only cellular structure which could be determined in the slime consisted of a few bacteria-like cells, but in insufficient numbers to produce the slime.

The explanation of the occurrence appears to be that the threads are produced by the large number of jellyfish *Aurelia* which inhabit the Sounds. At times the schools of *Aurelia* are extremely densely packed and of many yards in length. These jellyfish are a constant inhabitant of the Sounds, and some bays can always be found where the microplankton has completely disappeared owing to their depredations.

Apart from the presence of slime in June and July, 1935, the waters of Pelorus Sound contain, as a rule, much more silt or suspended detritus than is present in more open waters. Possibly this phenomenon also affects the spawning of the lemon soles.

An important previous record of the occurrence of slime is to be found in the 1901 report of the trawling expedition of the "Doto." Describing the result of trawling on the eastern side of Tasman Bay, Ayson states that when the trawl came up it contained a few gurnard, snapper, flounders, and shell-fish, also a quantity of dead fish. The shell-fish taken were also dead and the net was coated with slime. In 1938, also, slime at Napier seriously affected the fishing, and although a description of the slime from Tasman Bay and Napier is not at hand it is believed that in Tasman Bay the slime was similar to the 1935 epidemic in Pelorus Sound, while the recent occurrence at Napier was some form of phytoplankton.

FOOD.

The food of the lemon sole has in all cases been found to be exclusively benthic ; it consists of marine worms, chiefly *Nephthys macrura* and *Lagis australis*, and the ophiuroid *Amphiura rosea*. Fish taken in Pelorus Sound and in the more open parts of Tasman Bay fed almost without exception on annelids, while those taken in Admiralty Bay and off the Croisilles invariably contained *Amphiura*. This small brittle star was at times so plentiful that practically every inch of twine in the seine-net was covered with it.

In a study of the fishes of Otago Harbour, Graham (1939) found that the lemon sole fed on quite a varied diet, including one species of fish, the red cod. This may be a case of opportunism, a difficulty noted by Graham in the first part of the work. The mouth of the lemon sole is very small, and even a large fish would have difficulty in swallowing another fish 2 in. in length.

Following is a summary of the food of the lemon sole compiled from the results given in Graham's paper :—

Pisces : *Physiculus bachus.*
Mollusca : *Maorimactra ordinaria, Zethalia zelandica, Nucula nitidula.*
Crustacea : *Paramithrax* sp., *Halicarcinus* spp., *Hombronia depressa, Nectocarcinus antarcticus, Munida gregaria.*
Annelida : *Lepidonotus polychroma, Eulalia microphylla.*
Echinodermata : *Ophiuroidea.*

The habit of feeding on the five species of tolerably fast-moving crustacea mentioned above indicates that lemon soles in Otago Harbour must be more active in their feeding-habits than those in Tasman Bay.

The inclusion of *Munida gregaria* is an interesting addition and indicates the tremendous importance of this crustacean in the food of fishes in southern waters. Of the fish mentioned in Graham's paper approximately half (twenty-eight species) had *Munida* in their stomachs.

THE STOCK OF FISH.

1. Measurements of Fish.

At the commencement of the work in October, 1934, measurements of fish constituted practically the whole of the work done, and properly tabulated measurements over a period of years would give a valuable guide to changes in the stock of fish. This survey of one year is, of necessity, incomplete, but, used in conjunction with other data collected on growth and spawning-habits, some valuable facts have been elucidated.

Table 1 gives the measurements of the total fish measured from all areas. Apart from showing the range in size of the catch, the table in itself is of little value in determining the actual composition of the stock.

The only outstanding irregularity in the graphical representation on page 43 is at 25 cm., and this is most likely a chance variation. Considering the number of 25 cm., the probably error is 9·3, and the possible range is then $205 \pm 3 \times 9{\cdot}3$ (Jones, 1927, p. 151).

From the formula $r_n = \pm 0.6745\sqrt{\frac{n\,(S-n)}{S}}$

Where r_n is the probable error, n the number at 25 cm., and S the total number in sample.

The length frequency curve of the lemon soles is similar in type to that given by data in the English Plaice Investigation, Table VIII (Thursby-Pelham, 1932). The graph on page 43 shows the curve for the females given in Table VIII. The probable error at 15 cm. is 10·7 and the possible range is then $44 \pm 3 \times 10{\cdot}7$, which shows that the variation at 15 cm. is insignificant. Groups I, II, and III fish are also shown on the graph, and examined in this light the random variation is most evident in group III fish.

In the tabulation of the measurements given in the present work each area as shown in Fig. 5 has been treated separately. By this method certain similarities are at once obvious, and Tasman Bay fish are shown to be a homogeneous class. Admiralty Bay and Pelorus Sound fish together represent a homogeneous whole, and similarly Queen Charlotte Sound fish are distinct. Fish from these three areas are shown separately in Tables 2 and 3.

The method used in testing differences in these areas was similar to that described for the possible variation at a given length. As a basis of comparison fish above and below 28 cm. were taken as a test and the probable error worked out. The following table shows the differences in stock in three areas:—

Area.	Percentage under 28 cm. and Possible Variation.
(*a*) Tasman Bay	49·6 ± 2·3.
(*b*) Admiralty Bay and Pelorus Sound	25·9 ± 2·7.
(*c*) Queen Charlotte Sound	13·3 ± 10·3.

From these figures there is a possibility that Queen Charlotte Sound is related to the previous area (*b*), but such a relationship is not likely.

There are three possible explanations of the differences in the stocks existing in the three areas:—

(1) Fishing in one place may have more serious effects on the population than in another:

(2) There may be varying quantities of food available, or other environmental factors may influence the growth-rate differently:

(3) There may be distinct races of fish.

(1) One of the effects of over-fishing is to increase the number (or the percentage) of small fish. Lemon soles in Tasman Bay at the time the sampling was carried out were not fished so much as in Admiralty Bay, and yet the percentage of small fish is greater in Tasman Bay. Queen Charlotte Sound is also fished still less than Tasman Bay, and the percentage of fish under 28 cm. is much less, so the effects of fishing may be eliminated as a cause of the differences in the stocks of Tasman Bay and Admiralty Bay fish. The reason for the different intensities of fishing in Tasman Bay and Admiralty Bay is that the lemon-sole ground in Tasman Bay is particularly exposed and as a result receives much natural protection owing to weather. Admiralty Bay, on the other hand, like Pelorus Sound, is particularly sheltered, and fishing may be carried out in all but very bad weather in both these places. Queen Charlotte Sound had not been fished by a trawler or a seiner for a number of years prior to the samples being taken, the reason being that it was closed to these classes of boats in order to protect other species of fish. It may be mentioned that lemon soles are not taken in any quantity by other methods of fishing in operation.

(2) Environmental factors are not possible of exact determination, but no great differences in temperature for the two important areas, off the Croisilles and Admiralty Bay, were observed, and the food brought up in the net seemed equally abundant. The fact that fish from all localities make considerable migrations makes the factor of environment still more indefinite, but as it is the youngest fish which have spent the great part of their lives near the spawning-grounds that are concerned there does not seem to the writer sufficient justification to assign the difference in the stocks to differences in the environments. Moreover, the available evidence of growth points to a similar growth-rate for these two areas.

Queen Charlotte Sound fish, however, perhaps owing to the practical absence of fishing for a long period of time, appear to be quite a distinct race. There are no large fish such as one would expect to find on a virgin fishing-ground, and small fish are scarce. Several otoliths of fish from Queen Charlotte Sound indicate that the growth-rate is appreciably slower than in the other localities.

(3) By a "race of fish" no specific difference is implied, but merely a difference in spawning-ground and consequent dependence of the stock on the conditions existing in that locality. The writer believes that a certain amount of mixing of the stocks takes place, due to the drift of eggs and to migrations of the adults. Such a movement, however, cannot be demonstrated until marking experiments are carried out.

The hypothesis that distinct races of fish are present has the advantage that there are differences in the spawning-grounds for two of the suggested races, and no doubt Queen Charlotte Sound, which is about fifty miles from either of the other grounds, has its own particular area in which the stock is replenished, but it has not yet been discovered.

The location of a spawning-ground in Pelorus Sound indicates that there should be a separate stock of fish in this place; but, as mentioned on page 33, spawning in this area has never appeared to be at all on the same scale as in the two other known spawning-grounds, and it is believed that Pelorus Sound receives the main part of its stock from the easterly drift of eggs from Admiralty Bay.

2. Age-determination.

The only reference to the age of New Zealand marine fish is by Finlay (1928), who finds that lemon soles "increasing from three to four years of age, according to the otolith readings, show an increase from 10 in. to 13 in. in length," a rate quite in agreement with the results found in the present work.

Scales have been found quite impossible to read, but otoliths give fairly consistent readings, which it is believed show the age with a reasonable degree of accuracy.

In 1935 otoliths and scales were collected and preserved in small tubes 2 in. by $\frac{3}{4}$ in. with a solution of glycerine 50 c.c., water 45 c.c., and formalin 5 c.c., according to the method of Dannevig, A. (1933). This solution prevents the otolith from becoming opaque and keeps it soft for grinding sections. Sections of those otoliths which were difficult to read were made by rubbing the otolith on a glass plate covered with a thin paste of fine carborundum. Otoliths preserved in glycerine and formalin solution can be sectioned very quickly by this method. Before mounting in balsam, otoliths with uncertain reading were often cleared considerably by treating in xylol. Clearing in this manner is necessary because if the grinding is continued too long the pattern of rings is completely erased.

In order to show the difficulties met with in connection with the age-determination of the lemon sole an outline of the facts discovered in the case of the sand flounder (*Rhombosolea plebeia*) is given first, for while this species presented some difficulties of its own they were not so puzzling as was the case of the lemon sole.

The three main facts on which the proof depends, that the light and dark rings in the otolith are formed in summer and winter respectively, are, for the sand flounder, as follows:—

(1) All otoliths taken in April show a clear margin of rapid growth, and those taken in June show a margin of slow growth.

(2) A record of growth of sand flounder kept at the Portobello marine fish hatchery (Thomson, G. M., 1921) gives March to May as the period of slowest growth, and the growth per year is given as 4½ in. –in accordance with the growth found in Tasman Bay.

(3) In the English Plaice Investigations (Thursby-Pelham, 1932) it was found that by using a cover net over the cod end smaller fish were caught and these considerably reduced the average size of the youngest age-group present in the commercial catches—*i.e.*, the average size of the youngest fish in commercial catches was not in conformity with that of older fish, because, owing to the selective action of the net, only the largest of the young fish were captured. The otolith readings of the sand flounder, taken in commercial catches, show this discrepancy in average size of young fish in a striking manner—*e.g.*, the average sizes of males in Groups II and III are respectively 19·4 cm. and 21·4 cm.

In the lemon sole the otoliths also show a zoning of dark and light rings. The April collections show a clear margin, those taken in May a narrow margin of slow growth, which is still more pronounced in the June collections, but in July and August (during the spawning-season) some had a margin of slow growth and some a clear margin of rapid growth. Those fish taken in shallow water, mainly on non-spawning grounds, had the winter ring formed, while a few fish taken on spawning-grounds had often a clear edge to the otolith. It is believed these latter migrated from deep water.

A consideration of the temperature shows that although surface temperatures of shallow waters in New Zealand are higher, the annual variation is approximately the same as in the North Sea, where, in the open waters, the surface temperature of the water varies by about 10° C. during the year.

For comparison, temperatures from a comparable locality in the North Sea are given, together with temperatures from Cook Strait. The three series given include the average, maximum, and minimum temperatures recorded for the year. North Sea temperatures are from the Atlas de Température et Salinité (Conseil International 1933). The Cook Strait temperatures are from the Engineer's Log of the Wellington to Picton Ferry-boat, 1934–35.

	55° 47′ N. 5° 53′ E.	Tasman Bay.	Cook Strait.
February	4·3	21·3 (1935)	15·0 (1937)
April	6·6	17·5 (1935)	13·3 (1936)
August	16·4	10·8 (1935)	10·5 (1936)
November	10·3	18·7 (1934)	12·8 (1936)

The temperature of the bottom water was taken by tying a quart bottle to the lead line, and when the required depth had been reached the cork was withdrawn with a second line, and the bottle hauled rapidly to the surface. Temperatures taken in this way often showed a distinct difference from those taken at the surface, being up to 2° C. warmer in the winter. It has not been possible to obtain a bottom temperature for the summer, but the temperature difference would be equally as great, since warm water of less density would tend to float on the surface more than cold water. From this it follows that in water over 30 fathoms deep, where fishing could not be carried out, there is not the same temperature variation as there is in shallow water. In a previous section it was stated (page 30) that lemon soles are present in water over 30 fathoms deep, and it is believed that for part of the year they make extensive migrations to deep water and consequently avoid the extremes of temperature found in more shallow water.

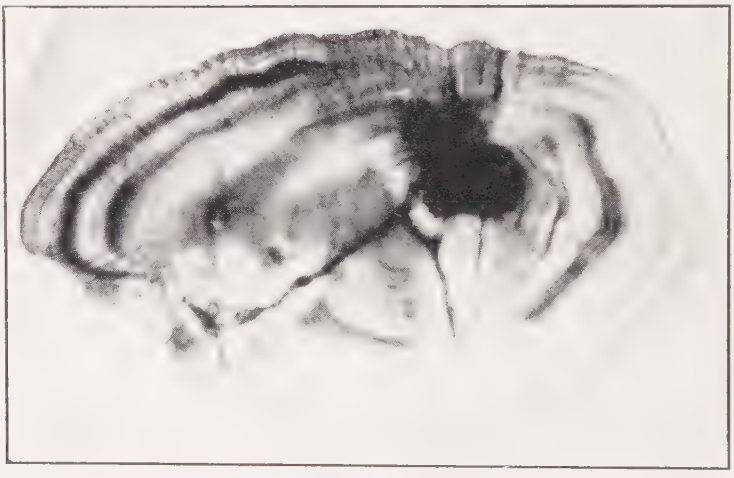


FIG. 16.—Section of an otolith of a group V lemon sole taken in August, 1935. Photograph taken by transmitted light; the darker bands indicate the periods of slow growth. Length of fish, 30 cm.

The surface temperatures given for Cook Strait were taken between Wellington Heads and Tory Channel. They show less than half the variation of the more sheltered water of Tasman Bay, and no doubt there is also some difference between surface and bottom temperatures, so the bottom temperature would vary by less than the surface temperatures.

It is considered that the differences in time of formation of the dark and light zones are caused by the different habitats; fish inhabiting shallow water are influenced by the cold, and winter bands are formed. On the other hand, fish in deep water do not experience the same variation in temperature, but the zone of slow growth which forms in the otolith is a spawning check. Figure 16 is of an otolith of a fish in its fifth winter.

The evidence of age of the lemon sole may be summarized as follows:—

(1) Young fish inhabiting shallow water clearly show the different growth-rates in summer and winter.

(2) Fish taken on the spawning-grounds do not always show dark and light zones of winter and summer growth, but the dark rings may be spawning-marks.

(3) The large average size of Group II fish present in commercial catches (Table 10) is not in conformity with that of older fish. A similar state of affairs was found in the case of the sand flounder, and it is shown to a very marked degree in the tables given by Thursby-Pelham (1932). The large size is due to the selective action of the net. Although the evidence is indirect it is considered not without weight.

Owing to differences in the times at which the winter or spawning check occurs and, initially, to the prolonged period over which the spawning-season extends, the age of fish cannot be determined exactly from an examination of the otoliths.* Some interesting points on the growth can be found from an examination of data in Table 10. Group II fish are seen to vary in size from 20 cm. to 30 cm. in length. These fish are roughly between one and two years old, and it may safely be said that both male and female lemon soles reach a size of 23 cm. (9 in.) after two complete years growth. That is, the smallest fish in commercial hauls are only two years old.

To complete the data on growth-rate the following table gives the weight in grammes of male and female fish at each centimetre of length.

The measurements were made during the month of July when the fish were full of roe; no spent fish are included:—

Live-weight of Lemon Soles.

Length, in Centimetres.	Females.		Males.	
	Number of Fish weighed.	Average Weight, in Grammes.	Number of Fish weighed.	Average Weight, in Grammes.
23	2	140	..	..
24	3	160	7	160
25	4	175	7	185
26	6	255	2	195
27	7	275	5	210
28	14	315	4	255
29	10	335	3	285
30	13	390	4	310
31	21	420	2	380
32	17	445	1	395
33	13	495	3	425
34	8	565	1	450
35	8	520	..	..
36	10	615	..	..
37	3	690	..	..
38	2	695	..	..

* Another method used in making tables of age is to assign a particular day as "birthday" for the whole population; thus the 1st of July could be used as "birthday" in the case of lemon soles.

No definite conclusions as to the rate of increase in weight can be drawn, but referring the lengths of fish of the different age-groups in Table 10 to the weights given above an approximate estimation of the variation in weight can be obtained.

The average weight of Group III fish is approximately 160 grammes (6 oz.) for males and 270 grammes (10 oz.) for females; of Group IV fish 255 grammes (9 oz.) for males and 496 grammes (17 oz.) for females.

Data in the table given on page 41 shows that the male weighs less than a female of equal length and, referring also to Table 10, the male increases in length more slowly than the female. There is also evidence that he is shorter lived.

The considerable variation in size of the fish, especially in the lengths of the females of the various age-groups, is partly due to differences in the fishing-grounds.

3. Undersized Fish.

Of some importance to a practical administration of the lemon-sole fisheries is the number of fish under the legal size of 9 in. which are taken in the seine-net. Quite a valuable record now exists of the varying numbers of undersized fish which have been taken from different grounds. With several exceptions, the number of fish in each sample recorded was between 200 and 500:—

Percentage of Lemon Soles under 23 cm.

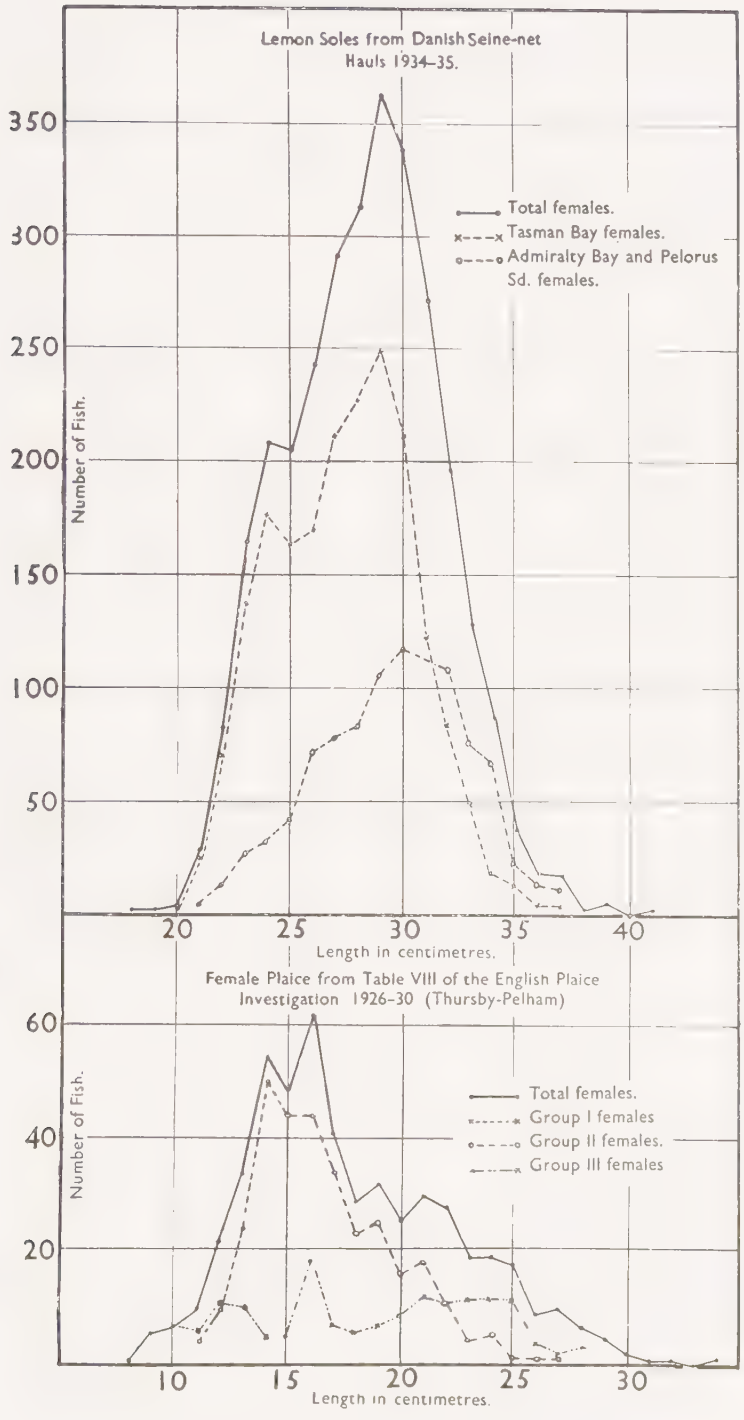
Year.	Mesh of Cod End.	Tasman Bay.		Admiralty Bay.		Pelorus Sound.	
	In.						
1934 ..	$4\frac{1}{4}$	6·8	Oct., Nov. ..	3·3	Jan., 1935 ..	2·3	Jan., 1935.
1935 ..	4	11·5	June, July ..	1·3	Aug. ..	5·8	June, July.
1936 ..	5	1·0	Aug. ..	..	..	2·4	May, July.
1937 ..	$4\frac{3}{4}$	4·8	June ..	0·0	Aug. ..	0·6	July.
1938 ..	$4\frac{3}{4}$	..		1·3	Aug. ..	3·3	Aug.

Measurements of the cod end varied considerably for the hauls made in Tasman Bay and Pelorus Sound. In 1935 the mesh of the cod end measured approximately $3\frac{7}{8}$ in. with the exception of January, 1935, when the measurement was $4\frac{1}{4}$ in.

In 1936 the legal-size mesh for the cod end of Danish-seining vessels was increased to 5 in. For Pelorus Sound in 1936 the size of the cod end varied from $4\frac{3}{4}$ in. to $5\frac{1}{4}$ in., while for Tasman Bay in August, 1936, the cod end measured only $4\frac{1}{2}$ in.

The effect of the 1936 regulation is shown by a rearrangement of the data given previously.

Locality.	Number of Fish, 1934–35.	Percentage of Undersized Fish, 1934–35.	Number of Fish, 1936–38.	Percentage of Undersized Fish, 1936–38.
Tasman Bay ..	964	8·0	232	1·3
Admiralty Bay ..	681	1·6	311	1·0
Pelorus Sound ..	482	5·2	323	1·6


Lemon Soles from Danish Seine-net Hauls 1934–35.
Total females.
Tasman Bay females.
Admiralty Bay and Pelorus Sd. females.
Number of Fish.
350
300
250
200
150
100
50
20
25
30
35
40
Length in centimetres.
Female Plaice from Table VIII of the English Plaice Investigation 1926–30 (Thursby-Pelham)
Total females.
Group I females
Group II females.
Group III females
Number of Fish.
60
40
20
10
15
20
25
30
Length in centimetres.

Although some variation in size of the cod end is permitted, the effect of the regulation was to increase the size of the mesh of the cod end by a $\frac{1}{2}$ in.

Of the fish measured on the various grounds this has effected an average decrease from 6·1 per cent. to 1·3 per cent. in the number of fish under 9 in. Tabulated above are the percentages of undersized fish from three localities; in all cases there is a decrease in the percentage of undersized fish caught.

SUMMARY.

(1) A *résumé* of some previous taxonomic work on the lemon sole is given and some further details of variation in the adult are added.

(2) In the development it was found that the first black pigment appears in the form of minute granules, yellow pigment is in chromatophores. The first black chromatophores appear some time after the yolk-sac is absorbed.

(3) A series of free swimming stages is described up to the time when a bottom living habit is acquired.

(4) Free swimming larvæ are taken mainly in sheltered bays.

(5) The adults are scattered for the greater part of the year, but in the spawning-season congregate in well-defined areas.

(6) The most important spawning-month is August.

(7) Two-year-old fish on the spawning-grounds were found to be spawning or almost ready to spawn.

(8) There is evidence of the occurrence of different stocks of fish in Tasman Bay, Admiralty Bay and Pelorus Sound, and Queen Charlotte Sound.

(9) Increasing the legal size of the mesh of the cod end from 4$\frac{1}{2}$ in. to 5 in. has resulted in decreasing the proportion of fish under 9 in. in certain commercial catches from 6·1 per cent. to 1·3 per cent.

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(2) To Messrs. M. Neilson and V. Sussex, who have on a number of occasions allowed their boats to be used for the purpose of examining and measuring a large number of fish.

(3) To Mr. Dougal Hope, who was in charge of the launch from which most of the tow-netting was carried out and to whose uncanny knowledge of the sea-bottom much of the success of these operations was due.

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TABLE 1.—LEMON SOLES: TOTAL FISH CAUGHT AT EACH CENTIMETRE OF LENGTH, OCTOBER, 1934, TO AUGUST, 1935.

	Length, in Centimetres.																							Total.
	<18.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	32.	33.	34.	35.	36.	37.	38.	39.	>39	
Males ..	2	1	3	11	21	72	166	169	203	193	139	128	66	61	29	15	6	1	..	1	..	..	..	..	1,293
Females ..	1	1	1	4	29	82	165	209	205	244	292	313	362	339	272	197	128	89	37	17	16	2	5	1	3,011
Total ..	3	2	4	15	56	154	331	378	408	437	431	441	428	400	301	212	134	90	37	18	16	2	5	1	4,304

TABLE 2.—MALE LEMON SOLES CAUGHT AT EACH CENTIMETRE OF LENGTH FROM TASMAN BAY, ADMIRALTY BAY, PELORUS SOUND, AND QUEEN CHARLOTTE SOUND.

	Length, in Centimetres.																						Total.
	<18.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	32.	33.	34.	35.	36.	37.	38.	39.	
Tasman Bay	..	1	2	8	27	45	97	95	97	86	45	41	10	10	1	1	..	..	..	1	..	..	..	561
Admiralty Bay and Pelorus Sound	..	..	..	3	6	27	67	74	101	102	88	77	52	48	26	12	4	1	..	..	..	..	..	688
Queen Charlotte Sound	2	..	1	..	..	..	2	..	5	5	6	10	4	3	2	2	2	..	..	..	..	..	..	44
Total	2	1	3	11	27	72	166	169	203	193	139	128	66	61	29	15	6	1	..	1	..	..	..	1,293

TABLE 3.—FEMALE LEMON SOLES CAUGHT AT EACH CENTIMETRE OF LENGTH FROM TASMAN BAY, ADMIRALTY BAY, PELORUS SOUND, AND QUEEN CHARLOTTE SOUND.

	Length, in Centimetres.																							Total.
	<18.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	32.	33.	34.	35.	36.	37.	38.	39.	>39.	
Tasman Bay ..	1	1	1	3	25	70	138	176	164	169	213	228	249	211	121	84	48	18	12	3	3	..	..	..	1,938
Admiralty Bay and Pelorus Sound	..	..	..	1	4	12	27	32	41	71	78	83	106	118	145	109	76	67	23	14	13	2	5	1	1,028
Queen Charlotte Sound	..	..	..	..	..	..	..	1	..	4	1	2	7	10	6	4	4	4	2	..	..	..	..	..	45
Total ..	1	1	1	4	29	82	165	209	205	244	292	313	362	339	272	197	128	89	37	17	16	2	5	1	3,011

Table 4.—Lemon Soles: Total Catches of Males and Females, and the Percentage of Males for each Area.

Area.	Number of Hauls.	Males.	Females.	Percentage Males.	Total.
1A	4	1	23	4	24
1B	22	84	650	11	734
2	10	52	111	32	163
3	46	329	940	26	1,269
4	6	5	33	13	38
5	10	83	179	32	262
6	1	7	2	..	9
Total for—					
Tasman Bay	99	561	1,938	22	2,499
Admiralty Bay, 8	12	281	437	39	718
Pelorus Sound, 9	43	407	591	41	998
Queen Charlotte Sound, 10 ..	2	44	45	49	89
Total	156	1,293	3,011	30	4,304

TABLE 5.—LEMON SOLES CAUGHT EACH MONTH IN EACH AREA.

Date.	Area.	Number of Hauls.	Males.	Females.	Total.	Number per Haul.
1934.						
October ..	1A	1	..	1	1	1
	1B	11	24	375	399	36
	3	4	15	91	106	26
November ..	1B	7	34	226	260	37
	3	3	7	50	57	19
1935.						
January .	8	4	75	43	118	29
	9	4	30	58	88	22
February ..	1B	1	7	3	10	10
	2	2	20	32	52	26
	3	14	179	356	535	38
	4	2	1	..	1	.
March	2	1	4	8	12	12
	3	11	65	153	218	20
	5	5	26	87	113	22
	6	1	7	2	9	9
April	9	18	161	173	334	19
	10	2	44	45	89	44
May	1B	3	19	46	65	22
	2	1	12	12	24	24
	3	4	41	56	97	24
	5	3	12	13	25	8
	9	11	74	130	204	19
June	1A	2	1	21	22	11
	2	1	12	32	44	44
	3	8	22	218	240	30
	4	3	4	29	33	11
	9	4	59	70	129	32
July	2	5	4	27	31	6
	3	1	..	15	15	15
	4	1	..	4	4	4
	5	2	45	79	124	62
	9	6	83	160	243	40
August ..	1A	1	..	1	1	1
	3	1	..	1	1	1
	8	8	206	394	600	75
Total ..	..	156	1,293	3,011	4,304	28

TABLE 6.—MATURITY OF FEMALE LEMON SOLES, JUNE, 1935.

Locality: North of Pepin Island, Areas 2 and 3.

	Length, in Centimetres.												
	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	32.	Total.
Immature	1	1	3	2	..	..	..	..	..	..	..	..	7
Ripening	1	1	3	7	7	6	3	1	1	..	..	1	31

TABLE 7.—MATURITY OF FEMALE LEMON SOLES, JULY, 1935.

Locality		Length, in Centimetres.																		
		18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	32.	33.	34.	35.	36.	Total.
Off Pepin Island, 17/7/35	Immature	..	..	..	..	1	1	4	1	..	..	..	..	..	..	..	..	..	..	..	7
	Ripening	1	5	..	2	5	2	2	3	..	1	3	..	..	..	..	..	..	..	..	24
Total		1	5	..	2	6	3	6	4	..	1	3	..	..	..	..	..	..	..	..	31
Two miles north of Pepin Island, 22/7/35	Immature	..	..	..	..	2	1	..	..	..	..	..	..	..	..	..	..	..	..	..	3
	Ripening	..	..	..	..	3	4	4	..	..	1	2	..	..	..	..	..	..	..	..	14
Total		..	..	..	..	5	5	4	..	..	1	2	..	..	..	..	..	..	..	..	17
Pelorus Sound, Beatrix Bay, 19–20/7/35	Immature	..	1	..	1	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	3
	Ripening	..	..	..	1	5	6	6	8	11	13	14	9	15	13	19	11	11	3	3	148
	Spawning	..	..	..	..	..	..	..	1	..	1	..	..	..	2	..	2	4	1	1	12
	Spent	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	..	..	2
Total		..	1	..	2	5	6	7	9	11	14	14	9	15	15	19	14	16	4	4	165
Off Croisilles Harbour, 21/7/35	Immature	..	1	..	..	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..	3
	Ripening	..	..	..	1	1	2	6	4	4	12	6	10	4	6	6	3	2	3	1	71
	Spawning	..	..	..	..	..	..	..	..	..	..	..	1	..	..	1	1	..	..	..	3
	Spent	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	1	..	..	2
Total			1	..	1	1	2	6	5	4	13	6	11	4	7	7	4	3	3	1	79

TABLE 8.—MATURITY OF FEMALE LEMON SOLES, AUGUST, 1935.

Locality		Length, in Centimetres																					Total.
		21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	32.	33.	34.	35.	36.	37.	38.	39.	40.	41.	
Catherine Cove and Admiralty Bay, 26–30/8/35	Immature	..	..	1	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2
	Ripening	1	..	2	5	8	11	14	17	17	24	25	16	9	12	2	3	5	..	2	..	..	173
	Spawning	..	..	..	1	1	11	7	3	8	7	7	3	8	6	2	2	..	1	..	..	..	67
	Spent	..	..	.	.	2	4	1	3	4	4	4	6	3	1	1	..	..	..	..	..	1	34
Total		1	..	3	6	11	26	23	23	29	35	36	25	20	19	5	5	5	1	2	..	1	276
Admiralty Bay between Clay Point, and Penguin Bay, 30/8/35	Immature ..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
	Ripening	..	..	..	2	2	1	4	3	2	1	7	5	1	3	1	..	..	..	1	..	..	33
	Spawning	.	..	..	2	5	5	5	3	8	10	12	11	10	5	1	..	..	..	..	..	..	77
	Spent	..	1	..	..	..	..	..	..	..	2	2	..	..	2	..	..	..	..	..	..	..	7
Total . ..	..	.	1	..	4	7	7	9	6	10	13	21	16	11	10	2	..	..	..	1	..	..	118
Admiralty Bay, 26–30/8/35	Immature ..	.	.	1	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Ripening ..	1	.	2	7	10	12	18	20	19	25	32	21	10	15	3	3	5	..	3	..	..	206
	Spawning ..	..	..	..	3	6	16	12	6	16	17	19	14	18	11	3	2	..	1	..	..	..	144
	Spent ..	..	1	..	.	2	4	1	3	4	6	6	6	3	3	1	..	..	..	..	..	1	41
Total	..	1	1	3	10	18	33	32	29	39	48	57	41	31	29	7	5	5	1	3	..	1	394

TABLE 9.—NUMBER OF MALE LEMON SOLES AT EACH CENTIMETRE LENGTH MILTING AND NOT MILTING, AUGUST, 1935.

Locality: Admiralty Bay, 26–30/8/35.	Length, in Centimetres.												Total.
	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	32.	33.	
Milting ..	2	8	10	18	23	15	19	12	6	5	4	2	124
Not milting ..	3	9	8	10	15	9	14	2	8	2	1	1	82
Total ..	5	17	18	28	38	24	33	14	14	7	5	3	206

TABLE 10.—AGE OF LEMON SOLES TAKEN IN THE DANISH-SEINE NET, APRIL TO AUGUST, 1935.

Male, M.; female, F.

Lengths, in Centimetres.	Age-group.													
	I.		II.		III.		IV.		V.		Over V.		Total.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
13	2	..	..	..	..	..	..	..	..	..	..	..	2	..
14	..	..	..	..	..	..	..	..	..	..	..	..	..	..
15	..	..	..	..	..	..	..	..	..	..	..	..	..	..
16	..	..	..	..	..	..	..	..	..	..	..	..	..	..
17	..	..	..	..	..	..	..	..	..	..	..	..	..	..
18	..	..	..	..	..	..	..	..	..	..	..	..	..	..
19	..	..	..	..	..	..	..	..	..	..	..	..	..	..
20	..	..	1	..	..	..	..	..	..	..	..	..	1	..
21	..	..	..	3	..	1	..	..	..	..	..	..	..	4
22	..	..	2	..	2	..	..	..	..	..	..	..	4	..
23	..	..	1	1	2	2	..	..	..	..	..	..	3	3
24	..	..	..	1	1	1	..	..	..	..	..	..	1	2
25	..	..	1	1	1	3	..	..	..	..	..	..	2	4
26	..	..	..	1	..	1	..	..	..	..	..	..	..	2
27	..	..	1	1	..	3	..	1	..	..	..	..	1	5
28	..	..	..	1	..	..	1	1	..	..	..	..	1	2
29	..	..	..	..	..	2	..	..	1	..	..	1	1	3
30	..	..	..	..	..	..	1	..	..	1	..	..	1	1
31	..	..	..	1	..	..	..	1	1	..	..	..	1	2
32	..	..	..	..	..	..	..	1	..	..	..	..	..	1
33	..	..	..	..	..	2	..	..	..	1	..	..	..	3
34	..	..	..	..	..	..	..	1	..	..	..	..	..	1
35	..	..	..	..	..	..	..	3	..	1	..	..	..	4
36	..	..	..	..	..	..	..	..	..	..	..	1	..	1
37	..	..	..	..	..	..	..	1	..	..	..	..	..	1
Average size ..	13·5	..	22·9	25·2	23·7	27·0	28·8	33·2	30·5	33·5	..	33·0	..	..
Number ..	2	..	6	10	6	15	2	9	2	3	..	2	18	39

TABLE 11.—RECORD OF TOW-NETTINGS IN WHICH LEMON-SOLE OVA AND POST-LARVAE WERE TAKEN.

Duration of tow = Ten minutes.

Date.	Haul No.	Net Diameter in Inches.	Locality.	Depth of Water, in Fathoms.	Depth of Net.	Number of Ova.	Number of Post-larvæ.
28/7/36	1	18	Pelorus Sound, Beatrix Bay	23	Surface ..	4	..
,,	2	18	Beatrix Bay ..	23	Bottom	7	..
31/7/36	3	36	Off slipface, N. Croisilles Harbour	25	Surface ..	65	..
,,	4	36	N. Croisilles Harbour	25	Bottom	45	..
2/8/36	5	36	2 m. N. of Croisilles Harbour	28	,,	23	..
,,	6	36	3 m. N. of Croisilles Harbour	28	,,	40	..
,,	7	18	4 m. N. of Croisilles Harbour	28	Surface ..	9	..
,,	8	18	4 m. N. of Croisilles Harbour	28	Bottom	1	..
,,	9	18	4 m. N. of Croisilles Harbour	28	Mid-water	9	..
,,	10	36	5 m. N. of Croisilles Harbour	28	,,	11	..
4/8/36	18	18	Pelorus Sound, off St. Omer	13	,,	2	..
,,	19	18	Pelorus Sound, off Fairy Bay	15	,,	1	..
,,	20	18	Pelorus Sound, off Maori Bay	6	Surface ..	1	..
,,	21	18	Pelorus Sound, off Miro Bay	8	,, ..	4	..
6/8/36	22	18	Pelorus Sound, Beatrix Bay	23	Bottom	2	..
,,	23	36	Pelorus Sound, off Beatrix Bay	23	Mid-water	17	..
,,	24	26	Pelorus Sound, off Kauauroa Bay	14	Bottom	6	..
,,	25	18	Pelorus Sound, Kauauroa Bay	14	,,	4	..
,,	26	18	Pelorus Sound, off Port Ligar	35	Ca., 30 fathoms	4	..
,,	27	36	Harding Pt., Chetwodes	30	Surface ..	25	..
,,	28	36	,,	30	Mid-water	27	..
,,	29	36	Admiralty Bay, E. shore	25	Surface ..	16	..
2/9/36	30	36	Admiralty Bay, Tainui Passage	30	,, ..	1	..
,,	31	36	Admiralty Bay, N. of Tainui Passage	30	Mid-water	..	2
,,	32	18	Ditto	30	Surface ..	1	..
3/9/36	33	36	Admiralty Bay, off Cannibal Cove	20	,, ..	1	..
,,	34	36	Catherine Cove, off Cherry Bay	25	,, ..	2	..
,,	36	36	Admiralty Bay (Turners Bay)	28	Mid-water	1	1
,,	37	36	Clay to Harding Point	28	Surface ..	3	..
4/9/36	39	36	Harding Point ..	30	,, ..	3	..
,,	40	36	Pelorus Sound, Port Ligar, N. shore	14	,, ..	1	..
,,	43	36	Pelorus Sound, Beatrix Bay, W. shore	23	Bottom	2	2

ABLE 11.—RECORD OF TOW-NETTINGS IN WHICH LEMON-SOLE OVA AND POST-LARVAE WERE TAKEN—*continued.*

Duration of tow = Ten minutes.

Date.	Haul No.	Net Diameter in Inches.	Locality.	Depth of Water, in Fathoms.	Depth of Net.	Number of Ova.	Number of Post-larvæ.
6/9/36	47	36	Pelorus Sound, Kauauroa Bay, E. shore	14	Bottom	1	..
,,	49	36	Ditto	6	,, ..	1	..
,,	50	36	Pelorus Sound, Kauauroa Bay, W. shore	8	,, ..	1	2
,,	51	36	Pelorus Sound, Beatrix Bay, middle	23	,, ..	..	3
8/9/36	54	36	Port Gore, Pig Bay ..	15	,, ..	1	14
9/9/36	56	36	Queen Charlotte Sound, Tory Channel	12	Surface ..	1	..
1/12/36	61	36	Tasman Bay, Two Beach Bay	4	Bottom	..	7
,,	64	36	Croisilles Harbour (Maori Bay)	7	,,	..	1
5/12/36	79	36	Cable Bay	2	,,	3	..
,,	81	36	Whangamoa ..	2	,,	1	..
6/12/36	86	36	Admiralty Bay (Huritini)	7	,,	..	10
,,	89	36	2 m. N.E. of Rangitoto Island	18	,,	..	1
,,	90	36	Admiralty Bay (Penguin Bay)	14	,,	..	1
,,	91	36	Admiralty Bay (Rocky River)	9	,,	..	23
7/12/36	92	36	Forsyth B., S. shore ..	4	,,	..	2
,,	93	36	,, ..	4	,,	..	4
,,	94	36	,, ..	4	,,	..	2
/12/36	97	36	Pelorus Sound, Nydia Bay, N. shore	2	,,	..	1
/12/36	121	36	Admiralty Bay, E. side, ½ m. S. of Clay Point	15	,,	..	1
4/2/37	124	36	Catherine Cove (Cherry Bay)	4–20	,,	..	1
,,	125	36	C. Cove (Head) ..	7	,,	..	2
,,	126	36	,, ..	6	,,	..	3
,,	127	36	,, ..	6	,,	..	2
,,	128	36	C. Cove (Centre) ..	25	,,	..	2
4/6/37	182	36	Admiralty Bay, S. off Rabbit Island	12	,,	1	2
,,	184	36	Catherine Cove (out of Cherry Bay)	1–20	,,	3	1
5/6/37	185	36	Admiralty Bay (Penguin Bay)	6–10	,,	8	..
,,	186	36	Ditto	6–10	,,	14	..
,,	187	36	Admiralty Bay (Whareatea Bay)	2–12	,,	3	..
,,	188	36	Ditto	10	,,	3	..
,,	190	36	Catherine Cove, E. side	16	,,	1	..
,,	191	36	C. Cove (Head) ..	2–6	,,	3	..
7/6/37	200	36	Pelorus Sound (Crail Bay)	18	Mid-water	1	..
9/6/37	209	18	Titirangi Bay (Ghost Bay)	10	,,	2	..
3/6/37	227	36	Admiralty Bay (Huritini)	9–10	Bottom	1	..
,,	228	36	Admiralty Bay (Rocky River)	6	,,	2	..

TABLE 11.—RECORD OF TOW-NETTINGS IN WHICH LEMON-SOLE OVA AND POST-LARVAE WERE TAKEN—*continued.*

Duration of tow = Ten minutes.

Date.	Haul No.	Net Diameter in Inches.	Locality.	Depth of Water, in Fathoms.	Depth of Net.	Number of Ova.	Number of Post-larvæ.
13/6/37	229	36	Admiralty Bay (Hamilton Bay)	4–8	Bottom	8	5
,,	232	36	Admiralty Bay (Deep Bay)	18	,,	1	3
,,	234	36	Admiralty Bay, Halfway Deep Bay to Huritini	28	,,	..	2
,,	235	36	Ditto	28	,,	..	2
31/7/37	237	36	Penguin Bay, S. side	10	,,	10	..
,,	238	36	Waterfall Bay ..	17	,,	6	..
,,	239	18	,, ..	17	Surface ..	2	..
1/8/37	240	36	Two Beach Bay ..	5	Bottom	12	..
,,	241	18	,, ..	5	Surface ..	7	..
,,	242	36	,, ..	28	Bottom	10	1
,,	243	36	,, ..	28	Surface ..	15	..
,,	245	36	Okure Bay ..	20	Bottom	20	..
2/8/37	247	36	Kauauroa Bay ..	8	,,	5	..
4/8/37	249	36	Catherine Cove (Head)	10	,,	7	..
,,	250	36	Catherine Cove, E. shore	20	,,	2	..
,,	251	36	Catherine Cove (Centre)	28	,,	5	..
,,	252	36	,, ..	28	Mid-water	5	..
,,	253	18	,, ..	28	Surface ..	3	..
,,	254	18	Off D'Urville Peninsula	28	1 fathom	8	..
,,	255	36	Off Penguin Bay ..	28	Bottom	12	..
,,	256	36	Admiralty Bay (Centre)	28	,,	7	..
5/8/37	257	36	Huritini	7	,,	25	..
,,	261	36	Deep Bay	18	,,	24	..
,,	264	36	Cannibal Cove ..	12	,,	18	..
,,	266	36	Off Whareatea ..	18	Surface ..	1	..
8/8/37	272	36	Sandy Bay (W. side D'Urville Island)	8	Bottom	2	..
2/8/38	276	36	Ditto	12	,,	5	..
,,	277	36	S.W. of Bottle Point	15	Surface ..	3	..
,,	278	36	Port Hardy ..	18	Bottom	7	..
,,	279	36	,, ..	15	Surface ..	4	..
5/8/38	281	36	Admiralty Bay (Rocky River)	15	Bottom	2	1
,,	282	36	S. of Rocky River ..	20	,,	3	..
,,	283	36	Midway Deep Bay, Huritini	28	,,	3	..
,,	284	36	Ditto	28	,,	4	3
,,	285	36	Hamilton Bay ..	28	,,	10	1
12/8/38	292	36	Catherine Cove (Centre)	20	,,	24	1
,,	293	36	Cherry Bay ..	15	,,	15	..
,,	294	36	Penguin Bay ..	10	,,	40	..

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